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*SOME RECENT APPLICATIONS OF FUNCTION THEORY TO PHYSICAL PROBLEMS.**

IT has seemed appropriate that the address of the retiring chairman should draw attention to some of the most recent developments in those sciences which it is the object of this Section of the Association to promote, especially to some problems that seem to be making but slow headway, and to others that are at a standstill for want of appropriate modes of mathematical expression.

In selecting a particular group of problems I have been guided by the thought that there is one field of work which touches the domain of every member of this Section, whether his or her immediate interests lie in abstract mathematics, in physical mathematics or in astronomy. I mean the great field of the theory of functions of a complex variable.

The physicist or astronomer who wishes to understand the true nature of any function which he deals with must study its behavior on the complex plane, its zeros, its poles, its singularities and perhaps its Riemann surface. Moreover, in dealing with such important questions as stability

* Address by the retiring Vice-President and Chairman of Section A—Mathematics and Astronomy—of the American Association for the Advancement of Science, Pittsburgh meeting, June 28 to July 3, 1902.

and instability it is necessary to examine the region of convergence of the infinite series which so often present themselves; and this cannot be done with certainty without the methods of function theory.

In such cases we use the function theory to test the character of the solutions already obtained, and to find out the regions within which they are applicable; but in the discovery of solutions of new physical problems the methods of general function theory have seldom been used. It is chiefly of its use as an instrument of discovery that I wish to speak to-day.

It has long been known that the theory of functions of a complex variable is useful in treating the numerous physical problems whose solution can be made to depend on Laplace's equation in two dimensions,

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0.$$

This equation presents itself in the theory of the two-dimensional potential, and in problems relating to the steady flow of heat, of electricity and of incompressible fluids.

The essential feature of the method in question is to take an arbitrary function of the complex variable, and to express this function in the form

$$f(x+iy) = \phi(x, y) + i\psi(x, y),$$

in which φ and ψ are real functions of two real variables, x and y.

The functions φ and ψ are then said to be conjugate to each other, and are in all cases solutions of Laplace's equation, whatever be the assumed function f.

Moreover the two families of curves

$$\phi(x, y) = C_1,$$
$$\psi(x, y) = C_2$$

(in which $C_1$and C_2 are arbitrary constant parameters) cut each other at right angles. The curves of one system may be taken as equipotential lines, and those of the other system will then be lines of force, or lines of flow. The physical boundary of the region must be some one of the lines of either set.

Some interesting applications of this method to tidal theory have recently been made by Dr. Rollin A. Harris in his 'Manual of the Tides,' published by the U. S. Coast and Geodetic Survey.* I would mention especially his use of an elliptic function as the transforming function in the form

$$x + iy = sn(\phi + i\psi).$$

The two sets of orthogonal curves drawn by him may be seen in the *Annals of Mathematics,* Vol. IV., page 83. By imagining thin walls erected along certain of the stream lines, we see, for instance, the nature of the flow around an island lying between two capes.

The direct problem of determining a solution of Laplace's equation that shall be constant at all points of a boundary previously assigned is usually very difficult. It is a particular case of what is commonly known as the Problem of Dirichlet. Before stating this problem it is convenient to define a harmonic function. Any real function $u(x, y, z)$ which satisfies Laplace's equation, and which, together with its derivatives of the first two orders, is one-valued and continuous within a certain region, is said to be harmonic within that region. Dirichlet's problem may then be stated as follows:

To find a function $u(x, y, z)$ which shall be harmonic within an assigned region, T, and which shall take assigned values at points on the boundary surface S.

This problem has long been one of the meeting grounds of mathematicians and physicists. Some important mathematical theories have received their starting point from this and similar 'boundary-value problems.'

* Part IV., A, pp. 574–82.

In proving that a solution always exists, Dirichlet began by assuming as self-evident that among all the functions which satisfy the assigned boundary conditions, there is a certain function, u, for which the integral

$$\int\int\int\left[\left(\frac{\partial u}{\partial x}\right)^2+\left(\frac{\partial u}{\partial y}\right)^2+\left(\frac{\partial u}{\partial z}\right)^2\right]dxdydz,$$

taken throughout the region T, is a minimum. This assumption is usually called 'Dirichlet's principle.' If this principle be granted it can be shown by the calculus of variations that the function u satisfies Laplace's equation; and it is easy to prove by Green's theorem that there is no other solution.

It was first pointed out by Weierstrass that this assumption is not allowable. If only a finite number of quantities present themselves we can assume that there is a smallest one among them. But among an indefinite number of quantities in any assigned group a smallest one does not necessarily exist. Consider for instance those rational numbers which decrease towards the square root of 2 as a limit; there is no smallest among them.

This led mathematicians to seek for other proofs of the existence theorem; and many interesting developments in function theory have been the result. Very recently Hilbert has reexamined Dirichlet's assumption, and has succeeded in demonstrating it, so that it is once more available as a starting point for the existence theorem.

When the boundary of the region is rectangular, circular, spherical, cylindrical, conical or ellipsoidal, the appropriate harmonic functions will be found in such works as Byerly's 'Fourier Series and Spherical Harmonics.'

I may mention here a new method of obtaining solutions of Laplace's three-dimensional equation used by Dr. Harris, and applied to tidal problems.* He uses the more general complex variable containing two imaginary units i and j. An arbitrary function of the form

$$\phi(ax+iby+jcz)$$

is a solution of Laplace's equation, provided $i^2=j^2=-1$, and $a^2=b^2+c^2$. When this function is expanded, the real part, and the coefficients of i, of j and of ij, are all separate solutions of the differential equation. A great number of solutions of this and similar equations can be obtained by this method. It is to be hoped that Dr. Harris may have time to develop it further.

In order to lead up to some recent applications of function theory I wish to speak especially of another method of solving Dirichlet's problem, namely by the use of Green's function.

Green's function is defined as follows for a given closed boundary S and a given pole P_1, within the bounded region T.

Let (x, y, z) be the current point within the region, and let (x_1, y_1, z_1) be the pole. Then $G^{x,y,z}_{x_1,y_1,z_1}$ is to vanish at every point of the boundary S, and is to be harmonic within the region T except at the pole (x_1, y_1, z_1), where it is to become infinite as $1/r$, where r is the distance of the current point (x, y, z) from (x_1, y_1, z_1).

There is always one and only one Green's function for a given boundary and pole. The determination of the form of this function G furnishes a solution of Dirichlet's problem; for it has the property that the surface integral

$$\int\int V\frac{dG}{dn}dS,$$

taken over the boundary of S, has the value $4\pi V(x_1, y_1, z_1)$, where V is any function harmonic within S, and dG/dn is the normal derivative of Green's function. Hence the value of V at any point

* 'Manual of Tides,' Part IV., A, pp. 584, 597.

(x_1, y_1, z_1) within the boundary is expressible in terms of its surface values and the normal derivative of G. Thus the solution of Dirichlet's problem is reduced to a problem in integration when Green's function is known.

Some recent advances have been made in determining Green's function for certain boundaries. To make them clearer I shall begin with the simple problem of finding Green's function for a region bounded by two planes at right angles and extending to infinity. Here Lord Kelvin's method of images is directly applicable. Let P_2 be the image of the pole P_1 taken with regard to the first plane. Let P_3 be the image of P_2 with regard to the second plane; and P_4 the image of P_3 as to the first plane. Then the image of P_4 as to the second plane brings us back to the first point, P_1. These four poles form a closed system, and there is only one pole in the given region. The required Green's function is

$$\frac{1}{r_1} - \frac{1}{r_2} + \frac{1}{r_3} - \frac{1}{r_4}$$

in terms of the distance of the current point (x, y, z) from the four poles; for this function, being a potential function, satisfies Laplace's equation; it also vanishes on the bounding planes by symmetry, and at infinity; moreover it becomes infinite as $1/r_1$ at the pole P_1, and is infinite nowhere else within the bounded region.

It may be observed that a direct physical interpretation of Green's function is illustrated by this problem. It is evidently the combined potential due to a positive unit of electricity placed at P_1 and to the induced charge on the bounding planes made conducting and maintained at zero potential; for this distribution realizes the boundary conditions. Hence the induced charge due to P_1 is equivalent in effect to three-point charges, namely, a positive unit at P_3, and negative units at P_2 and P_4.

Next consider the problem in which the angle of the planes is not an aliquot part of π. The simplest case is when this angle is $2\pi/3$. Performing the successive reflections as before, it is found that there are five reflections before the image comes back to P_1. There are then six poles, of which two are situated in the given region. The function

$$\frac{1}{r_1} - \frac{1}{r_2} + \frac{1}{r_3} - \frac{1}{r_4} + \frac{1}{r_5} - \frac{1}{r_6}$$

satisfies all the conditions except that of having only one pole within the region. It is thus not the required Green's function; and Lord Kelvin's method of images does not furnish a solution.

This method fails in two large classes of problems: (1) When the successive images (or poles) do not form a closed system; (2) when more than one of these poles lie within the assigned region.

By the conception of a Riemann space, Dr. Sommerfield* has recently made the important advance of overcoming the difficulty arising from the presence of two poles within the region. He regards the whole region as undergoing successive reflection; and thus, in the problem last mentioned, the whole of space is filled twice over. He imagines a two-fold Riemann space having the intersection of the planes as a winding line, and one of the planes as a branch membrane. The appropriate coordinates are cylindrical (r, θ, z). The axis of z is the line of intersection, and the plane $z=o$ is the plane passed through the original pole P_1, perpendicular to the axis of z. The radius-vector r is the distance of the current point from the z-axis, and θ is the angle which r makes with one of the planes, taken as initial plane.

* *Proc. Lond. Math. Soc.*, 1897, 'Ueber verzweigte Potentiale im Raum.'

When any radius vector OP revolves about the axis of z, it remains in the first (or physical) space until $\theta = 2\pi$. It then crosses the branch membrane and enters the second fold of the Riemann space. In the problem before us, a second revolution brings the radius vector into the first fold again. It is to be understood that each fold fills all space. Two underlying points have the same r and the same z, but their θ coordinates differ by 2π or some odd multiple of 2π. Two points whose vectorial angles differ by an even multiple of 2π are in the same fold.

The problem now is to find a Laplace's function which shall vanish on each plane and at infinity, and shall have only one pole in the original physical space between the planes.

Let (r_1, θ_1, z_1) be the coordinates of the assigned pole, and (r, θ, z) those of the current point. Then $1/R$ is a solution of Laplace's equation, where

$$R^2 = (z - z_1)^2 + r^2 + r_1^2 - 2rr_1 \cos(\theta - \theta_1).$$

Dr. Sommerfeld first replaces θ_1 by an arbitrary parameter α, and denotes the result by R'. He then multiplies $1/R'$ by an arbitrary function $f(\alpha)$, and integrates with regard to α. The result is still a solution of Laplace's equation. By a proper choice of the function $f(\alpha)$, and of the range of integration, he obtains a function of (r, θ, z) satisfying all the conditions. He takes the two-valued function

$$f(\alpha) = \frac{e^{\frac{i\alpha}{2}}}{e^{\frac{i\alpha}{2}} - e^{\frac{i\theta_1}{2}}},$$

and puts

$$u_1 = \frac{1}{4\pi} \int \frac{1}{R'} \frac{e^{\frac{i\alpha}{2}}}{e^{\frac{i\alpha}{2}} - e^{\frac{i\theta_1}{2}}} d\alpha,$$

then regards α as a complex number, and performs the integration in the α-plane around a contour enclosing the point $\alpha = \theta_1$ and excluding the other points where the integrand becomes infinite. The function u_1 thus obtained becomes infinite at the pole (r_1, θ_1, z_1) but does not fulfill the condition of vanishing on the two planes. Next he forms a similar function u_2 for the pole P_2 situated at (r_2, θ_2, z_2), and so on. The required Green's function is

$$u = u_1 - u_2 + u_3 - u_4 + u_5 - u_6.$$

The poles of u_1 and u_4 would, under ordinary circumstances, both lie in the given region, but the pole of u_4 is given such a vectorial angle as to bring it into the second fold of the Riemann space. The function u has then only one pole for the physical region defined by $0 < \theta < 2\pi$.

Moreover, u vanishes for points on the two planes, and fulfills all the other conditions for Green's function.

Thus we see how a function, which would be two-valued and bi-polar if restricted to the given physical region, becomes single-valued and uni-polar in the Riemann space. We may say that the second fold of this space is a refuge for the second value and the second pole. Care has to be taken to use the proper values for θ when the indicated operations are being performed. The difficulties of the problem are thus reduced to those of the integral calculus.

In the more general case in which the angle of the planes is $n\pi/m$, there are $2m$ poles in the circuit (one in each angle π/m), of which n are in the given region. The Riemann space is then n-fold.

Sommerfeld has worked out at length the very interesting case in which the angle between the planes is 2π. The region is then bounded by the surfaces $z = \pm\infty$, $r = \infty$, $\theta = 0$, $\theta = 2\pi$; the last two being the two faces of an infinite half plane with a straight edge. The assigned pole and its image are both in the given region; hence the corresponding Riemann space is two-fold; and the required solution is

$$\bar{u} = u(\theta_1) - u(-\theta_1)$$

where u is of the same form as u_1 written above.

By inversion with regard to different centers, various other problems are reduced to this one; for instance, the infinite plane with a circular aperture, the circular disc, and the spherical segment.

With regard to the uniqueness of the solution, Dr. Sommerfeld has proved by a remarkable use of function-theory methods that a function satisfying the conditions already laid down for Green's function is uniquely determined in a Riemann space.

I next speak of some recent advances in the solution of an equation more general than Laplace's, namely, the differential equation

$$\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}+k^2 u=0,$$

which plays such an important part in the treatment of vibrating systems of various kinds; and I may introduce them by a quotation from Pockels' treatise on this equation: "Those solutions of our differential equation, which in accordance with their physical significance are regarded as single-valued within certain bounded regions, would by analytical continuation over the boundary in general become multiform. Therefore, from both a mathematical and a physical standpoint, multiform functions are important, and it is very desirable that the properties of such functions, their winding points and singularities, their behavior on Riemann surfaces, etc., should be systematically investigated—in short, all the function-theory questions which were handled in the theory of the Newtonian and logarithmic potential. * * * "Similarly as we have treated of solutions that are single-valued in the whole plane, it would be of interest to seek functions which are single-valued on a closed Riemann surface, or in an analogous three dimensional region, more especially those functions which are everywhere finite and continuous, namely the so-called 'principal solutions,' within the region in question. Finally there is the further investigation of the essential singularities and the natural boundaries which the functions satisfying this equation may present. * * * Investigations regarding these questions have not yet been made, more especially the integration of our equation for a closed manifold has hardly been touched. In this direction of inquiry without doubt a wide and rich field offers itself."

These words were written in 1890; and in 1897 appeared Professor Sommerfeld's paper on multiform potentials of which I have given some account above. He and his pupil, Dr. Carslaw, have also attacked the multiform solutions of the more general equation to which Pockels refers.*

The first problem that presents itself is to find a solution that has no pole, and is multiform with period $2n\pi$, in the ordinary sense, but on a certain n-sheeted Riemann surface is uniform. The case $n=2$ solves the following well-known physical problem:

Plane waves of sound, light or electricity are incident on a thin infinite half plane bounded by a straight edge, to find the resulting diffraction of the waves.

This problem had previously been mentioned by Lord Rayleigh in the article on Wave Theory in the Encyclopædia Britannica in the following terms:

"The full solution of problems concerning the mode of action of a screen is scarcely to be expected. Even in the simple case of sound where we know what we have to deal with the mathematical difficulties are formidable, and we are not able to solve such an apparently elementary question as the transmission of sound past a rigid infi-

* *Proc. Lond. Math. Soc.*, 1898; *Zeitschrift*, 1901; *Proc. Edin. Math. Soc.*, 1901.

nitely thin plane screen bounded by a straight edge or perforated with a circular aperture.''

Again the same author says in his work on the 'Theory of Sound':*

''The diffraction of sound is a subject which has attracted but little attention either from mathematicians or experimentalists. Although the general character of the phenomena is well understood, and therefore no very striking discoveries are to be expected, the exact theoretical solution of a few of the simpler problems, which the subject presents, would be interesting.''

Accordingly the recent solutions of Sommerfeld and Carslaw are very welcome to mathematicians and physicists. A very brief sketch of the principle of the method may here be given.

Let the waves come from the direction $\theta = \theta'$, and be incident on the plane $\theta = 0$. In the (x, y) plane, or in the (r, θ) plane, the origin will be regarded as a winding point, and the line $\theta = \pi + \theta'$ a branch line. Start with the simplest solution of our differential equation, namely, that for undisturbed plane waves in infinite space,

$$u = e^{ikr\,(\cos\theta - \theta')};$$

replace θ' by α, multiply by the same two-valued function of α as before, and integrate around the point $\alpha = \theta'$ in the complex α-plane. The result of the integration is a multiform solution of period 4π. The solution of the physical problem is obtained by adding the multiform solution for waves coming from the direction θ' to that for the direction $-\theta'$. There is, of course, considerable difficulty in performing the indicated operations, but this does not diminish the theoretical value of the solution, as the difficulties belong only to the integral calculus.

* 'Theory of Sound,' Vol. II., p. 141.

The next problem in order is that of waves issuing from a point-source against the half-plane, either in two or in three dimensions.

In the latter case we start with the undisturbed solution in infinite space

$$u = \frac{e^{ikR}}{R}$$

and treat this function as we treated 1/R in the potential problem. We put poles at (r', θ', o) and $(r', -\theta', o)$, and take the physical space as defined by $0 < \theta < 2\pi$.

It will be found that the function

$$\bar{u} = u(\theta') + u(-\theta')$$

satisfies all the conditions in the assigned physical space.

In the corresponding two-dimensional problem, the starting point is the undisturbed solution

$$u = Y_0(kr),$$

where Y_0 is the Neumann function.

The same method is applicable to problems in the flow of heat, in which the equation

$$k\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} + \frac{\partial^2 u}{\partial z^2}\right) = \frac{\partial u}{\partial t}$$

is to be satisfied. The starting point is the solution for a point-source in an infinite solid

$$u = \frac{1}{(4\pi kt)^{\frac{3}{2}}} \exp\left(\frac{-R}{4kt}\right).$$

In his recent paper published in the *Zeitschrift,* Sommerfeld has extended the method so as to apply to the problem of Röntgen rays encountering an obstacle represented by the same half-plane. He obtains a multiform solution of Maxwell's equations, and adapts it to the physical conditions, comparing the results with experimental data.

The induced currents flowing in an infinite half plane have been studied by Mr. Jeans* by the multiform method, using a

* *Proc. Lond. Math. Soc.*, 1899.

Riemann space with a single winding line.

The next advance was to solve a problem in multiform potentials in a Riemann space with two winding lines. Such a case presents itself in finding Green's function for an infinite plane with an infinitely long strip cut out. Sommerfeld has treated this problem by the use of the bipolar coordinate system

$$\rho = \log \frac{r_1}{r_2},$$
$$\phi = \theta_1 - \theta_2.$$

This is the system used so skillfully by Maxwell in which the curves $\rho = C_1$, $\varphi = C_2$ form two orthogonal families of circles (or cylinders). The Riemann space will have the straight lines corresponding to $\rho = \pm \infty$ for winding lines, and the plane $\varphi = 0$ for branch membrane.

The work of obtaining solutions of our differential equations on other Riemann surfaces or spaces has yet to be done. The difficulty lies in finding an appropriate system of coordinates. This is an attractive field and seems worthy of the attention of the best pure mathematicians.

It is interesting to note that the idea of obtaining a new solution by integrating an old solution in the complex plane with regard to a parameter seems to have occurred independently to a Scotch mathematician (J. Dougal, *Proceedings Edinburgh Math. Soc.*, 1901). For instance he regards the Bessel function $J_n(kr)$ as a function of its order n, and integrates with regard to n. The Legendrian and other functions may be treated in the same way. New functions are thus obtained that satisfy various boundary conditions.

All that I have said illustrates the need there is for new forms of functional relationship. The more new functions we can invent the better; that is to say, functions with new and varied characteristic properties. We look to general function theory to supply them. One never knows how soon they may find suitable use in some field of pure or physical mathematics. I said at the beginning that a number of physical problems are at a standstill for want of an appropriate mode of mathematical expression. In proof of this I may here quote the words of a few experts in different lines of work.

Lord Rayleigh says,* "When the fixed boundary of a membrane is neither straight nor circular, the problem of determining its vibrations presents difficulties which in general could not be overcome without the introduction of functions not hitherto discussed or tabulated. A partial exception must be made in favor of an elliptic boundary."

I may note here that Mathieu solved the problem of the elliptic membrane by transforming the differential equation to elliptic coordinates (ξ, η), so that one coordinate ξ would be constant on an elliptic boundary, and then satisfying the equation by means of a product function

$$u = \varphi(\xi) \cdot \psi(\eta),$$

making φ vanish on the boundary. This method might seem promising for other boundaries; but Michell has proved that the elliptic transformation is the only one that leads to an equation capable of being satisfied in the product form.†

Lord Rayleigh says in another place:‡ "The problem of a vibrating rectangular plate is one of great difficulty, and has for the most part resisted attack. * * * The case where two opposite edges are free while the other two are supported has been discussed by Voigt."§

In connection with air vibration he says: "The investigation of the conductivity for various kinds of channels is an important

* 'Theory of Sound,' Vol. 1, p. 343 (2d ed.).
† *Messenger of Mathematics*, 1890.
‡ 'Theory of Sound,' Vol. 1, p. 372.
§ *Göttingen Nachrichten*, 1893.

part of the theory of resonators, but in all except a very few cases the accurate solution of the problem is beyond the power of existing mathematics.''*

Professor E. L. Brown in his report on hydrodynamics presented to the Boston meeting says: ''No problem of discontinuous motion in three dimensions has yet been solved. The difficulty is one which can be easily appreciated. The theory of functions deals with a complex of the form $x+iy$ and this suits all problems in two dimensions. But little has been done with a vector in three dimensions. Perhaps the paper on Potentials by Sommerfeld in the *Proceedings of the London Mathematical Society* last year may have some bearing on the problem; it is in any case worth serious study. The subject of discontinuous motion was set for the Adams prize in 1895. A solution for a solid of revolution was asked for, and it was generally supposed that the circular disc would be the easiest to attempt. No solution was sent in. One prominent mathematician who has aided considerably in the development of hydrodynamics mentioned that he had worked for six months and had obtained absolutely nothing. A magnificent reception therefore awaits the first solution.''

Mr. Hayford writes (in SCIENCE, 1898): 'The most important tidal problem before us is that of determining the relation between the boundaries (bottoms and shores) and the modification produced by them on the tidal wave.'

Professor Webster, in his report on recent progress in electricity and magnetism, presented to the Boston meeting, says: ''The problem of electrical vibrations in a long spheroid is next to be attacked, and then perhaps on surfaces obtained by the revolution of the curves known as cyclides. The introduction of suitable curvilinear coordinates into the partial differential equations will lead us in the case of the spheroid to new linear differential equations, analogous to, but more complicated than, Lamé's, and will necessitate the investigation of new functions and developments in series.''

Dr. Webster also commends to the attention of pure mathematicians the various differential equations which are to be found in Heaviside's electrical papers; more especially the question of existence theorems.

I may mention here that Hilbert in a recent volume of the *Archiv** suggests the question of proving an existence theorem for the solution of any differential equation subject to assigned boundary conditions.

Even a partial treatment of any one of these problems might open up new relationships, and widen the intellectual horizon. It is a hopeful sign that several pure mathematicians are turning their attention to such questions. Speaking at the Chicago Mathematical Congress in 1893, Professors Klein and Webster deplored the growing separation of the pure and physical branches of mathematics, and pointed out the great loss that would result to each of the divergent branches. The recent increased attention to mathematical history has enforced this opinion. The influence of Klein, Poincaré, Weber and others has been helpful as a corrective, on the continent of Europe. The British Universities have steadfastly treated mathematical physics as an organic part of mathematical discipline. The same statement could not be made with regard to all of the American Universities; but there are many signs of improvement. With a true historical instinct, this Section of the Association, and its ally, the American Mathematical Society, have exerted their influence for an

* 'Theory of Sound,' Vol. 2, p. 175.

* *Archiv Math. und Phys.*, 1901, p. 229.

organic union of the entire mathematical field. On the whole, the indications are that the separation which was so deplored ten years ago is now being arrested.*

Besides the discovery of new functions a useful work might also be done in the tabulation of old ones. Our sister Association in England has set us a good example in this respect. The tables of elliptic integrals given by Legendre ought to be extended; and tables for the elliptic functions would be welcomed. The Neumann function needs tabulation, and several others might be mentioned. The familiar functions ought also to be tabulated on the complex plane. The labor could easily be divided up. I have myself made a beginning of this kind of work by computing the trigonometric and hyperbolic sine and cosine of $x+iy$ for values of x and y ranging separately from 0 to $\frac{1}{2}\pi$ at intervals of .1; it was published in Merriman and Woodward's 'Higher Mathematics,' 1896, and I have already had my reward in the fact that one electrical engineer has told me that he has used this complex table in the application of vector-theory to alternating currents. In connection with the chart already referred to, Dr. Harris has given a convenient method of computing *snz, cnz, dnz*. My friend, Dr. Virgil Snyder, has tabulated, under Professor Klein's direction, the Weierstrass sigma and zeta functions for the case $g_3=0$. The tables extend over nine parallelograms in the complex plane at intervals of one twenty-fourth of each period. They are now being published in Martin Schilling's 'Modell Verlag' (Halle). The case $g_2=0$ will next be treated.

I have also drawn the attention of the Section on former occasions to the importance of tabulating certain fundamental integrals, so as to increase our stock of what are called 'known functions,' in terms of which many other integrals might be expressed. Among these were the two integrals

$$\int_0^x \log \sin x dx,$$

$$\int_0^x J_0(x) dx.$$

In all that has been said I have confined myself to things that have been forced on my own attention. Many members of this Section and of its esteemed affiliated Society know of other standing problems. Not to go beyond the list of past officers that lies before me, I see the names of Eddy, Woodward, Waldo and Ziwet, who could tell us of the new problems in mechanics and dynamics; Gibbs, Hyde or Macfarlane could speak for quarternions and vector analysis; Bigelow for the mechanics of the atmosphere; Hayford for geodetic and tidal problems; Story for invariant theory; Johnson for differential equations; Moore for function theory; Beman, Phillips or Strong for geometry and analysis; Miller for group theory. Then to speak for the various fields of astronomical work we have a noble band consisting of Newcomb, Young, Pickering, Langley, Hall, Harkness, Hough, Van Vleck, Eastman, Stone, Chandler, Doolittle, Comstock, Paul, Upton, Holden, Kershner, Frisby, Barnard, Hall, Frost and Lord.

It would seem that the work of the Section not only advances science, but tends to prolong life; for I find only two starred names in the list of officers since the Section was reorganized on its present basis twenty years ago.

Rogers and Ferrel have entered into the larger life; and their works do follow them, for they are being carried on to wider issues.

James McMahon.
Cornell University.

* This paragraph has been amplified since the address was read.

SECTION A, MATHEMATICS AND ASTRONOMY.

THE meeting of the section at Pittsburgh compared favorably with former meetings both in the number and character of the papers presented and in the attendance. The number of papers presented was twenty-four, mathematical papers predominating somewhat over astronomical. The attendance was better in the morning than in the afternoon sessions, on account of the large and attractive list of excursions planned for the afternoons by the Local Committee. The list of papers follows:

On the Adaptability of the Glycerine Clock to the Diurnal Motion of Astronomical Instruments, particularly those used in Photographing Solar Eclipses: Professor DAVID P. TODD, Amherst College Observatory.

In outline the glycerine clock is an accurately constructed cylinder, about four inches in diameter, in which travels a piston, the flow of the glycerine being controlled at any required speed or rate by means of a series of needle valves. By attaching a mirror or objective to a frame, equatorially mounted, the glycerine clock can be set under one arm of it, at any convenient distance from the axis, and the requisite rate for counteracting the diurnal motion of the sun can be given by means of the needle valves. This permits very heavy weights to be thrown on the piston, and therefore the vibration of the instruments by wind can be precluded. When the run of the piston is finished, the glycerine is pumped out of the top of the cylinder and forced back into the bottom, and the run is commenced over again.

On a Convenient Type of Finder for very large Equatorials: Professor DAVID P. TODD, Amherst College Observatory.

The object of a 'finder' is convenience. But in equatorials above twenty inches in aperture, the ordinary finder is necessarily mounted so far away from the axis of the great telescope that its use occasions much inconvenience, simply because of the distance of its eyepiece from that of the great tube. To obviate this difficulty, Professor Todd proposes to construct the finder with a pair of reflectors, either planes or prisms, set at 45°, and to mount the main part of its tube in rings or bearings. By turning the tube in these, the finder's eyepiece can be brought as near the eyepiece of the great tube as is desired, or pushed away from it to admit attachment or adjustment of subsidiary apparatus.

Series whose Product is Absolutely Convergent: Professor FLORIAN CAJORI, Colorado College.

This paper is a continuation of the subject as developed by the author in his previous papers (*Trans. of the Am. Math. Soc.*, Vol. II., pp. 25–36, 1901; SCIENCE, Vol. XIV., p. 395, 1901; *Bulletin of the Am. Math. Soc.*, Vol. VIII., pp. 231–236, 1902) and in the article of Alfred Pringsheim (*Trans. of the Am. Math. Soc.*, Vol. II., pp. 404–412, 1901). Some of the results previously obtained, relating to absolutely convergent products of two or more series, are generalized and the method of treatment is simplified. The construction of pairs of divergent series with real or complex terms is given, such that the product of the two series is not only absolutely convergent, but equal to any desired value, including zero.

A New Treatment of Volume: Professor G. B. HALSTED, University of Texas.

After the establishment of a sect-calculus, the area of a triangle is defined as the product of its base by half its altitude, this product being proved independent of the choice of base. Then the volume of a tetrahedron is defined as the product of the area of its base by one third its altitude, this product being proved independent of

the choice of base. The volume of a polyhedron is defined as the sum of the volumes of a set of tetrahedra into which it is cut, this sum being proved independent of the mode of partition into tetrahedra. Then a prismatoid is defined, and its volume proved

$$V = \frac{a}{4}(B + 3S).$$

Then all the ordinary solids are forms of prismatoids.

A New Solar Attachment: Herbert A. Howe, Director of the Chamberlin Observatory, University Park, Colorado.

This was a description of a small solar of simple construction devised by Mr. Orville F. Shattuck, a former pupil of Professor Howe. It was shown how the device, when attached to a universal instrument or engineer's transit, may be used for some simple astronomical observations, and for illustrating the principles of the equatorial coudé, the prism transit, the sextant and the almucantar.

On the Periodic Solutions of the Problem of Three Bodies: Professor E. O. Lovett, Princeton University.

Lagrange found five exact solutions of the problem of those bodies in each of which the bodies preserve an unvarying configuration which revolves with a uniform velocity. When the third body is of infinitesimal mass compared with the other two, it can describe small periodic orbits in the vicinity of the points where exact solutions exist. The latter points were called centers of libration by Gyldén, and Darwin calls the infinitely small body an oscillating satellite. Hill pointed out the fertility of the notion and made a splendid application of it in his lunar theory. Poincaré elaborated the mathematical theory in his celebrated researches and we owe to Darwin an extended collection of examples of periodic orbits.

One of the most recent investigations of such orbits is a suggestive paper by Charlier, in No. 18 of the *Meddelanden från Lunds Astronomiska Observatorium.* In the *Monthly Notices of the Royal Astronomical Society* for November, 1901, Plummer has discussed some of Charlier's results in a more general manner.

It is the object of Professor Lovett's paper to determine the imaginary centers of libration and their corresponding orbits, and thus complete the analytical solution proposed by Charlier. The results cannot be expected to fit the sky, but they may be of some interest to mathematical astronomers. It appears that there are real periodic orbits corresponding to imaginary centers of libration.

The Rate of the Riefler Sidereal Clock, No. 56: Professor Charles S. Howe, Case School of Applied Sciences.

In this paper Professor Howe gave the details and results of some careful series of experiments of a Riefler clock enclosed in a glass case from which the air had been partially exhausted. The mean daily rate for a trifle over three months was .116 of a second. The average daily variation from this mean was .015, and the maximum variation .022 of a second. The paper will be published in the *Astronomische Nachrichten.*

A Representation of the Coordinates of the Moon in Power Series which are Proved to Converge for a Finite Interval of Time: Dr. F. R. Moulton, University of Chicago.

It is proved in this paper that the differential equations which the motion of the moon must fulfill can be integrated as power series in certain parameters, and that the series converge for at least a certain

finite, determinable interval of time. The equations to be integrated are of the type

$$(1)\quad \frac{dx_i}{dt} = X_i(x_1, \cdots, x_n ; a_1, \cdots, a_j ; \beta_1, \cdots, \beta_k ; t) \quad (i=1, \cdots, n),$$

where the x_i are any variables defining the position and motion of the moon, and the a's and β's are parameters occurring in the differential equations.

Solutions as power series in the a's are sought of the form

$$(2)\quad x_i = \sum_{\mu_1, \cdots, \mu_j = 0}^{\infty} x^{(i)}_{\mu_1, \cdots, \mu_j} a_1^{\mu_1} a_2^{\mu_2} a_j^{\mu_j}, \quad (i=1, \cdots, n),$$

where the

$$x^{(i)}_{\mu_1, \cdots, \mu_j}$$

are functions of the time to be determined. Substituting (2) in (1) and equating to zero the coefficients of the various powers of the a's, it is found that after the

$$x^{(i)}_{0, \cdots, 0}$$

have been found the other coefficients are determined by linear non-homogeneous differential equations which can always be solved. The proof of the convergence of these series is made by employing suitable comparison differential equations.

There is nothing to prevent any of the β's being numerically equal to any of the a's. In fact, on the start all the parameters are a's, but before the integrations made those which occur in a special manner, as in the trigonometrical functions, may be called β's. When this is done in an appropriate manner all the

$$x^{(i)}_{\mu_1, \cdots, \mu_j}$$

are purely periodic functions of the time except the angular variables, each of which has one term which is proportional to the time. After a finite number of terms have been found they may be rearranged as Fourier series whose coefficients are power series in the a's, giving expressions of the same form as usually found by lunar theorists.

The advantages of this method are: (*a*) The series are known to converge, (*b*) every step is defined in advance and contains nothing arbitrary, and (*c*) the work is divided up in a convenient manner.

The Mass of the Rings of Saturn: Professor A. HALL, South Norfolk, Conn.

The mass of these rings was first determined by Bessel in 1831 from the motion of the apsides of the orbit of Titan. This motion is about half a degree in a year. But the action of the figure of the planet, and the attractions of the other satellites were neglected; and, as Bessel pointed out, the resulting mass of the rings was too great. This mass is 1/118, the mass of Saturn being taken as the unit.

In this paper an equation was formed containing two indeterminate quantities depending on the figure of the planet, the mass of the rings, and the masses of the three brighter satellites, Rhea, Dione and Tethys. The small resulting action of the other satellites was estimated. The coefficiency of these six indeterminate quantities can be computed with sufficient accuracy. The uncertainty in finding the mass of the rings arises chiefly from the lack of good values of the masses of the satellites. These masses must be found from the mutual perturbation of the satellites. Substituting the values of the masses of the satellites determined by Professor H. Struve, the principal coefficient depending on the figure of the planet was assumed to be 0.0222. The mass of the rings is 1/7092. It is probable that Struve's masses of the satellites are too small, and the above mass of the rings too great.

Saturn will soon return to our northern skies, and it is hoped that further observations and their dimensions will give good values of the constants of this interesting system.

On a Class of Real Functions to which Taylor's Theorem does not apply; and

On a Class of Transcendental Functions with Line-Singularities: Professor JOHN A. EISTAND, Thiel College.

In the first paper a class of real functions to which Taylor's theorem does not apply was discussed. Examples of such functions were given and the non-identity of the expansion with the function expanded was shown.

In the second paper a new type of transcendental functions fulfilling certain conditions within and on the unit-circle was discussed. These conditions are: *The function together with all its derivatives is finite and continuous within as well as on the unit circle;* which is a singular line for the function. The form of the functions is as follows:

$$f(z) = \Pi \frac{z-(1+a_\nu)e^{2\pi i\nu\alpha}}{z-(1+b_\nu)e^{2\pi i\nu\alpha}} e^{\Phi_\nu(z)},$$

where

$$\lim a_\nu = 0, \quad \lim b_\nu = 0,$$

α is an incommensurable number, and

$$\Phi_\nu(z) = \frac{(a_\nu - b_\nu)^{2\pi i\nu\alpha}}{z-(1+b_\nu)e^{2\pi i\nu\alpha}} + \tfrac{1}{2}\left[\frac{(a_\nu - b_\nu)e^{2\pi i\nu\alpha}}{z-(1+b_\nu)e^{2\pi i\nu\alpha}}\right]^2 + \cdots + \cdots + \frac{1}{\nu-1}\left[\frac{(a_\nu - b_\nu)e^{2\pi i\nu\alpha}}{z-(1+b_\nu)e^{2\pi i\nu\alpha}}\right]^{\nu-1}.$$

On a General Method of Subdividing the Surface of a Sphere into Congruent Parts: Mr. HAROLD C. GODDARD, Amherst College.

The problem was incidental to the practical problem of constructing a steel sphere one hundred feet in diameter, in connection with a new method of mounting a telescope, as outlined in an article in the *American Journal of Science* for June, 1902, by Professor David P. Todd, of Amherst College.

If a regular dodecaedron be inscribed in a sphere, planes determined by the center and each edge of the dodecaedron cut out on the sphere twelve equal regular spherical pentagons. If the vertices of each pentagon be connected with its center by arcs of great circles the surface of the sphere is divided into sixty congruent isosceles spherical triangles, whose angles are determined as 60°, 60° and 72°.

A Possible New Law in the Theory of Elasticity: Professor J. BURKITT WEBB, Stevens Institute of Technology.

Owing to the absence of Professor Webb at the time this paper was called for, it was presented only in abstract. The law referred to in the title is: "If the forcible change of the distance between two points in an elastic sytem changes the distance of two other points by a certain amount, then the same force applied to alter the distance of the two other points will change the distance of the first two points by the same amount."

On Extracting Roots of Numbers by Subtraction: Dr. ARTEMUS MARTIN, Washington, D. C.

A paper on 'Evolution by Subtraction' was published in the *Philosophical Magazine* for September, 1880, communicated by the Rev. F. H. Hummell, who ascribed the method to his friend and neighbor, the Rev. W. B. Cole. The rule given in Mr. Hummell's paper for finding the square root of any number is:

From any square number subtract the even numbers in succession, beginning with 2, until the remainder is less than the next even number to be subtracted. This remainder will be the square root sought.

The statement of the rule may be simplified as follows:

For the nth subtrahend add 2 to the preceding subtrahend. The last remainder will be the square root sought.

Or: For the nth subtrahend, multiply n by 2; the last remainder will be the square root sought.

To find the cube root of a number the rule is:

For the nth subtrahend, multiply n by 6 and add the preceding subtrahend; the last remainder will be the cube root sought.

Thus the first subtrahend is 6; the next $6\times2+6=18$; the third, $6\times3+18=36$; and so on.

For the fourth root, the rule is:

To find the nth subtrahend, multiply n^2 by 12 and add 2 plus the preceding subtrahend; the last remainder will be the root sought.

In the paper rules are given for finding the fifth, sixth, seventh, eighth, ninth and tenth roots, with examples.

General formulas for the nth subtrahend of any root (the mth) are:

$$s_n=(n+1)^m-(n^m+1),$$

or

$$s_n=s_{n-1}+(n+1)^m+(n-1)^m-2n^m.$$

It is shown in the paper that in all cases for all roots the number of subtractions to be performed is one less than the number of units in the root sought, and consequently the root equals number of subtractions plus 1.

A table of subtrahends containing the first ten subtrahends for the first eleven roots is appended to the paper. This table can be extended to any desired extent by the rules and formulas given.

The paper will be published in the *Mathematical Magazine.*

On the Determination of the Places of the Circumpolar Stars: Professor MILTON UPDEGRAFF, U. S. Naval Observatory.

The contents of this paper are: A sketch of previous work done on circumpolar stars, (2) a statement of the kind of work needed, and (3) some suggestions as to the best methods to be used in redeterminations of the coordinates of the circumpolar stars. The paper will be published in one of the astronomical journals.

Report on Quaternions: Professor ALEXANDER MACFARLANE, Lehigh University.

This paper will be printed in full in the *Proceedings* of the Association.

The Definite Determination of the Causes of Variation in Level and Azimuth of Large Meridian Instruments: Professor G. W. HOUGH, Dearborn Observatory, Evanston, Ill.

This was an elaborate discussion of the various styles of mounting for meridian instruments, and of the effects of changes of temperature in causing variation. The results of several long series of observations upon this effect were exhibited. Professor Hough's conclusion was that stone piers give the best results. The paper gave rise to some spirited discussion.

A New Founding of Spherics: Professor G. B. HALSTED, University of Texas.

Professor Halsted presented under this title some abstracts from a book which he is about to publish. The author made a simple set of assumptions: (1) of association, (2) of betweenness, (3) of congruence, and he then showed how, without the assumption that the straight line is the shortest distance between two points, or that the shortest path between two points on a sphere is on the great circle through them, or even that two sides of a triangle are together greater than the third, all the projective and metric properties of spherics are established.

Report on the Theory of Collineations: Professor H. B. NEWSON, University of Kansas.

Owing to Professor Newson's absence from the meeting, this paper could be presented only by title. It will be printed in full in the *Proceedings.*

Second Report on Recent Progress in the Theory of Groups of Finite Order: Professor G. A. Miller, Stanford University.

In the absence of Professor Miller this report was presented in abstract by Dr. W. B. Fite, of Cornell University. It will be published in the *Bulletin of the American Mathematical Society.*

Displacements Polygons: Professor J. Burkitt Webb, Stevens Institute of Technology.

Owing to the absence of Professor Webb at the time this paper was called for it was read by title.

Some Theorems on Ordinary Continued Fractions: Professor Thomas E. McKinney, Marietta College.

Let D be any positive integer not a perfect square, and let its square root be represented by an ordinary continued fraction. This paper determines the form of D so that the continued fraction representing its square root may have a period with one, two, three or four elements, and applies the results to the determination of the number of reduced forms in the class to which the indefinite quadratic form $(1, 0, D)$ belongs.

On the Forms of Sextic Scrolls of Genus One: Dr. Virgil Snyder, Cornell University.

In his classification of sextic scrolls of genus 1, Dr. Snyder employed the method of point correspondence between two plane sections and made use of the following theorems which were proved in one of his former papers: (1) The nodal curve (simple or composite) is of order 9; (2) every generator cuts four others, and (3) any non-reducible plane curve lying on the surface is of genus 1.

Thirty-three types are found, ten of which have a multiple conic. It will be published in the *American Journal of Mathematics.*

Transformation of the Hypergeometric Series: Professor Edgar Frisby, U. S. Naval Observatory.

If in the differential equation of the second order connecting the elements of the hypergeometric series

$$P=1+\frac{a\beta}{\gamma}x+\frac{a\beta(a+1)(\beta+1)}{1\cdot 2\cdot\gamma\cdot(\gamma+1)}x^2+\text{etc.}$$

$x^\mu P'$ be substituted for P, new relations are obtained in which P' takes the place of P, and the new elements are functions of the original elements. μ is determined from the condition that the new series must be of the same general form as the old. If, in addition, x be replaced by $1/x$ another series is obtained. From these two new series, by proper substitution of the new derived elements, are obtained almost by inspection, the twenty different series ordinarily given in works on differential equations.

Edwin S. Crawley,
Secretary.

SECTION G, BOTANY.

Section G of the American Association met in the Botanical Hall of Phipps Conservatory on the mornings of June 30 and July 3, 1902. In the absence of Professor D. H. Campbell, Stanford University, Professor C. E. Bessey, of the University of Nebraska, was elected acting Vice-President.

The abstracts of papers presented are as follows:

The Prevalence of Alternaria in Nebraska and Colorado During the Drought of 1901: George Grant Hedgcock, Lincoln, Nebr.

This paper gives a brief synopsis of observations made in various sections of Nebraska and Colorado during the severe period of drought in July and August of

the year 1901. The conditions which existed retarded the development of such fungi as *Cercospora* and *Phyllosticta,* but favored the growth of *Alternaria* upon the blighted leaves of a number of plants, especially those of the sugar beet, potato, pumpkin, cantaloupe and plantain.

Effect of Acetylene Gas-light on Plant Growth, Plant Environment and Plant Diseases: FRANK WILLIAM RANE, New Hampshire College, Durham, N. H.

The effect of acetylene gas-light has a marked effect upon plant growth, especially under glass, during the winter months. Experiments show more effect upon certain plants than others. Illustrated by photographs of plants.

Plant Environment and Plant Diseases: F. W. RANE.

Healthy plants seem to evince the law of self preservation to more or less an extent. Just how far certain well-known plant diseases are brought about through a misunderstanding of ideal environment is thought to be a problem with possible gradual solution. Plant depredations it is believed are not naturally associated with plants where the environment or culture is most favorable. Plant diseases and plant culture are closely associated. Examples are offered.

Soil Temperatures and Vegetation: D. T. MACDOUGAL, N. Y. Botanical Garden.

A description of a method of making observations on soil temperatures by means of the newly designed Hallock thermograph. The influence of the divergent temperatures of the soil and air is touched upon.

Conditions Influencing the Vitality and Germination of Seeds: J. W. T. DUVEL.

The above article treats of the vitality of seeds as affected by various climatic conditions, especially the deleterious influences of warm, moist climates such as we have in the Gulf States. The condition and methods for keeping seeds in such unfavorable climates are discussed at some length, showing that the first requisite for prolonged vitality of seeds is a reduction in the amount of hygroscopic moisture present, thereby diminishing the respiratory activity and consequently a prolongation of the life of the seeds.

Some Neglected Factors in Discussions of Heredity: GEORGE J. PEIRCE.

Certain influences to which organisms are exposed are constant in operation and intensity; there is no escape from these influences; they have never been eliminated in experiments, and their importance can only be guessed. Among these influences are the atmosphere, the earth as a whole, water, gravity, which have been uniform in physical and chemical properties for millions of generations, if not always. The reaction of the living organism to these influences should be considered in all discussions of heredity.

Sclerotinia Fructigena: J. B. S. NORTON, College Park, Md.

Studied by Woronin, Smith, and many others; conidial stage (monilia) destructive fruit disease; apothecia not previously discovered. Found abundant on buried peach and plum fruits two years old in many Maryland orchards; the disk appears just above ground. Description of apothecia, asci, spores, etc. Connected with monilia by many laboratory cultures on flowers, fruit, and various culture media. Cycle of development completed in a few days. Spores germinate in ten hours. Economic importance; fruits should be burned or otherwise destroyed.

A Bacterial Soft Rot of Certain Cruciferous Plants and Amorphophallus Sinense; A Preliminary Report: By H. A. HARDING and F. C. STEWART, N. Y. Agric. Exp. Sta., Geneva, N. Y.

The Finding of Puccinia phragmitis (Schum.) Korn. in Nebraska: John M. Bates, Callaway, Nebraska.

June 14, 1901, the writer found the æcidal stage on garden rhubarb, in Kearney; August 23 the next two stages were found on *Phragmitis* at Callaway, sixty-five miles northwest. This year he has found the æcidal stage on *Rumex Britannica, R. altissimus* and *R. crispus,* and on rhubarb in four gardens, thus completing the life history. It is thought to be new to this continent.

Notes on Diseases of Western Coniferæ: Hermann von Schrenk, Mo. Botanical Garden, St. Louis, Mo.

The coniferous trees of California, Oregon, Washington, Idaho and adjoining States are attacked by a number of fungus diseases, some of which destroy as high as forty per cent. of the standing timber. The most important diseases are caused by forms of *Trametes pini, Polyporus Schweinitzii, Polyporus Libocedris,* n. sp., *Echinodontium tinctorum, Polyporus officinalis.* The development of these fungi and the manner and extent to which they destroy the wood were described. Reference was made to the blue disease of Black Hills timber.

A Disease of Potato Stems in Ohio, Due to Rhizoctonia: Augustine D. Selby, Wooster, O.

The work of Duggar and Stewart in New York upon diseases caused by the sterile fungus *Rhizoctonia* and the recent preliminary publication by Rolfs upon potato failures in Colorado due to the same source, is already known to workers in plant pathology.

For more than a year past work has been in progress at the Ohio Experiment Station upon the *Rhizoctonia* on potatoes. During the present June outbreaks of a well-marked stem disease in Ohio, due to this source have occurred at several points in Ohio. Local areas of decay are situated both above and below the soil line; the most striking feature, however, is the characteristic rosette aspects of the central leaves of the plants attacked. By slight incurling of the leaves the affected plants may be readily discerned in walking through the field; apparently this characteristic is constant on a number of varieties. Ten per cent. or more of the plants have been found affected; doubtless larger percentages may occur.

Arachniotus trachyspermus, A new Species of the Gymnoascaceæ: C. L. Shear, Department of Agriculture, Washington, D. C.

Arachniotus is a genus of primitive ascomycete, described by Schroeter in 1893. Four species have thus far been described. The present species, which appears to be new, is the first thus far reported in this country so far as known to the author. It was isolated from diseased cranberries grown in New Jersey and grown in abundance in culture media. The fungus first forms a thin layer of fine snow-white hyphæ. Mature peridia are produced in from two to three weeks. These are globular, about $\frac{1}{2}$ mm. in diameter, consisting of a thin, loose layer of fine hyphæ which enclose a dense mass of spherical or subglobose asci borne at the apices of the much branched and interwoven fertile hyphæ. Asci are eight-spored. Spores almost colorless but in mass showing a faint greenish-yellow tint, rough, elliptical, 3.5 x 2.5μ.

An Instance of a Change in the Native Flora: Chas. E. Bessey, Lincoln, Nebr.

In Nebraska the little grass *Festuca octoflora,* has been common throughout the State ever since botanizing has been done, but it has never been a conspicuous plant. This year inquiries have been sent in to the University and Experiment Station from

nearly all parts of the State, accompanied by the remark that the grass had appeared for the first time. There is no question as to the much greater abundance of this grass the present year. It is of considerably larger size, also, than usual. The suggestion is made that the intense heat and drought of last year had to do with the greater abundance of this species of the present year.

In connection with this case attention is called to the fact that twenty-five years ago after the 'grasshopper raids' the farmers noticed the great abundance of *Sporobolus vaginæflorus,* which they called the 'grasshopper grass,' and supposed that it had been brought by the grasshoppers.

Note on the Fuel Value of Cottonwood: CHAS. E. BESSEY, Lincoln, Nebr.

On the plains where the cottonwood (*Populus deltoidea*) is very commonly planted, there is much prejudice against it as a tree having any other value than for shade and windbreak. It is regarded as having low fuel value. Some careful measurements and calculations made by the writer show that on account of its rapid growth it produces more heat-yielding fuel in a given time than the trees with which it is usually planted. On a given area in a given time more heat units may be produced than by the use of any other of the commonly planted trees.

Features of the Flora of Cuba: CHAS. LOUIS POLLARD, 1854 Fifth Street, Washington, D. C. (Illustrated with lantern.)

A general account of the Cuban flora with special reference to the ecological aspects. The various plant zones and plant formations of the island are described, and the characteristic flora of each discussed. The plants of economic or ornamental value are also briefly discussed.

The Origin of the Achromatic Figure in Pellia: CHARLES J. CHAMBERLAIN, Department of Botany, University of Chicago.

This investigation deals chiefly with the first two nuclear divisions in the germinating spore. For comparison, however, mitosis was studied in other phases of the life history. The principal conclusions are as follows: The stimulus to nuclear division comes from within the nucleus. The asters are cytoplasmic in origin. The caps come from the outer portion of the nuclear membrane or from a *Hautschicht* surrounding the nucleus. The appearance and disappearance of astral rays suggest that they are concerned in the movement of nuclear matter. The centrosphere is formed by the astral rays, not the astral rays by the centrosphere. This centrosphere represents a condition intermediate between the well-defined centrosphere of one of the thallophytes, and the centrosomeless condition of the higher plants. The spindle fibers, except the mantle fibers, grow from one pole to the other. In early stages two half spindles are often distinguishable.

Comparison of the Development of the Embryo Sac and Embryo of Claytonia Virginica and *Agrostemma Githago:* MEL T. COOK, Greencastle, Indiana.

Claytonia Virginica has one archesporium; it forms one, occasionally two, tapetal cells, four megaspore cells, of which the lower develops into the sac in the usual manner. Very little enlargement of the sac is evident until the four-celled stage is reached, but after that time it enlarges rapidly and bends to form almost a complete circle. The antipodals disappear early; the synergids persist until the embryo is quite large. In the formation of the embryo the cell division is very irregular; the basal cell of the suspensor is small;

only one cotyledon develops. The endosperm is peripheral.

In *Agrostemma Githago* we find from one to three archesporial cells, one or two tapetal cells and only two megaspore cells, of which the lower develops into the sac. Frequently two sacs begin to develop, but one is always absorbed before the two-celled stage is reached. The sac begins to enlarge after the four-celled stage, the principal enlargement being from the antipodal end and at right angles to the long axis of the sac. The antipodals persist for a short time, but the synergids disappear early. In the four-celled stage a zone of very thin walled cells surrounds the sac and the absorption of these cells is an important factor in the enlargement of the sac. A long beak is formed from the micropylar end of the ovule. The formation of the embryo is regular and the basal cell of the filamentous suspensor is very large. Both cotyledons develop. The endosperm is peripheral.

Studies in Phycomycete Fertilization: Sclerospora Graminicola (Sacc.): F. L. Stevens, A. & M. College, W. Raleigh, N. C.

The oosphere in *Sclerospora graminicola* is uninucleate, clearly resembling the general type exhibited in the *Peronosporeae* and in *Albugo candida,* but differing from the more primitive forms such as *Albugo bliti* and *A. Tragopogonis.* The antheridium bears several nuclei, but one only enters the antheridial tube. Simultaneous mitosis occurs here as in the related forms, zonation is a prominent phase in oogenesis and the cœnocentrum is a conspicuous organ in the oogonium.

Notes on Agrostis: A. S. Hitchcock, U. S. Dept. of Agriculture, Washington, D. C.

Synonymy of species of the genus *Agrostis* occurring in North American History of several names. Notes on some of the early species described by Triu and others.

The Absorption of Water; A Function of the Ligule and Stipulaceous Tissue of the Grasses: F. L. Stewart, Merrysville, Pa.

An account of observations and experiments proving that, coordinate with certain structural provisions for the conveyance from the leaf-blade of the grasses of dew and rainwater deposited thereon, the ligule and the connected tissues of the leaf-sheath actively absorb it and transmit it into the circulatory system of the plant, thus supplementing the supply of water derived from the root.

The Pith Cells of Phytolacca Decandra: Henry Kraemer, Philadelphia, Pa.

The pith of this plant is differentiated into two parts, a peripheral portion made up of active cells, and a central metamorphosed portion consisting of biconcave diaphragms composed of both active and inactive cells separated at regular intervals by cavities. The latter appear to be formed by the abstraction of water from the cells of this region, as a result of the development of other parts of the stem. This view as to their origin seems to be confirmed by the fact that in the process of drying that portion of the pith in the upper internodes, which is not already metamorphosed, becomes thus differentiated. The metamorphosed pith in *Phytolacca decandra* seems on the one hand to have a certain resemblance in origin to the hollow internodes of the stems of the Polygonaceæ and on the other hand to resemble the heterogeneous or modified pith of the Magnoliaceæ.

A Review and Criticism of the Botanical Curriculum of some of our Colleges and Universities—from the Student's Standpoint: E. Mead Wilcox, Auburn, Ala.

Special Haustorial Apparatus in connection with the Embryo Sac of Angiosperms: JOHN M. COULTER, University of Chicago.

A Note on the Vitality of the Spores of Marsilea: MARSHALL A. HOWE, N. Y. Botanical Garden, Bronx Park, New York City.

The Ascent of the Transpiration Stream: EDWIN BINGHAM COPELAND, Stanford University, California.

Chemical Stimulation and the Evolution of Carbon Dioxide: EDWIN BINGHAM COPELAND, Stanford University, California.

HERMANN VON SCHRENK,
Secretary.

ASSIGNMENTS OF GEOLOGIC AND PALEONTOLOGIC PARTIES.

THE following assignments of geologic and paleontologic parties of the U. S. Geological Survey have been made for the present field season:

Dr. Geo. I. Adams will make an areal and economic survey of the Yellville quadrangle in Arkansas, with special reference to the preparation of a report on the Arkansas lead and zinc district. He will be assisted by Professor A. H. Purdue and Mr. Ernest F. Burchard.

Dr. Geo. F. Becker will continue the supervision of the Division of Physical and Chemical Research and the preparation of a report embodying his investigations on the conditions of gold deposition in the Mother Lode of California.

Mr. J. M. Boutwell and Dr. J. D. Irving will study the mining geology of the Park City district, Utah.

Dr. J. C. Branner will continue areal surveys on the Santa Cruz quadrangle, California.

Mr. M. R. Campbell will continue the supervision of areal and economic work in New York, Pennsylvania, Ohio, Indiana, Kentucky, and West Virginia. He will be assisted by Messrs. Charles Butts, Lester H. Woolsey, Ralph W. Stone and Marcus Goldman in Pennsylvania; by Mr. Myron L. Fuller in New York and Indiana, and by Professors Geo. H. Ashley and L. C. Glenn in Kentucky.

Professor T. C. Chamberlin will continue the supervision of investigations in Pleistocene geology of the United States. He will be assisted by Professor R. D. Salisbury and Mr. W. W. Atwood in the Rocky Mountain region; by Frank Leverett and F. W. Taylor in Michigan, and by W. C. Alden in Wisconsin.

Professor W. B. Clark, with assistants, will continue the investigations of the geology of the Coastal Plain region in Maryland and Delaware, and of the Piedmont plateau of Maryland in cooperation with the Geological Survey of Maryland.

Dr. Whitman Cross will suspend his regular field work in Colorado for the present season and spend a portion of the year in the Hawaiian Islands for the purpose of investigating volcanic phenomena.

Professor T. Nelson Dale will continue his surveys in western Vermont and will survey the Slatington quadrangle in eastern Pennsylvania. He will be assisted by Professor Frederick B. Peck and Mr. Fred H. Moffit.

Dr. William H. Dall will continue his studies for the completion of the revision of the Tertiary faunas of Florida.

Mr. N. H. Darton will continue areal surveys in the Black Hills and the Big Horn Mountains, and will complete a reconnaissance of the Great Plains for the preparation of a map showing the geology and water resources of that region. He will be assisted by Mr. C. A. Fisher.

Mr. J. S. Diller will complete the areal and economic survey of the Redding quad-

rangle, California, and make a reconnaissance of the Klamath Mountains. He will be assisted by Dr. Geo. B. Richardson.

Mr. Geo. H. Eldridge, who has recently completed a study of the oil fields of California, will devote the coming year to the preparation of a report on this subject, and on the phosphate deposits of Florida.

Professor B. K. Emerson will continue his investigations on the areal and structural geology in central Massachusetts.

Mr. S. F. Emmons will continue the supervision of investigations in the Division of Metalliferous Minerals, visiting various mining regions in the West for the purpose of examining work in progress, and preparing plans for future work. He will be assisted by Dr. J. D. Irving in the completion of work on the Leadville mining district.

Dr. N. M. Fenneman will continue the investigation of the Boulder oil field, Colorado.

Mr. G. K. Gilbert does not expect to carry on any field work, but will be engaged throughout the year in the preparation of reports.

Dr. Geo. H. Girty will investigate the paleontology and stratigraphy in connection with the work of various geologists in Arkansas, Indian Territory, Texas, and elsewhere.

Mr. Arnold Hague will continue the preparation of his monograph on the Yellowstone National Park and will visit the Park for the purpose of obtaining necessary additional information.

Dr. C. W. Hayes will continue the supervision of investigations on non-metalliferous economic deposits, and will continue areal work in the southern Appalachians. He will be assisted by Mr. W. T. Griswold in the eastern Ohio oil field, and by Mr. Edwin C. Eckel in Alabama and Georgia.

Mr. Robert T. Hill will continue his investigation of the economic geology, stratigraphy, physiography and vulcanism in the trans-Pecos region of Texas, New Mexico and Arizona. Dr. Girty will be associated with him in this work.

Dr. T. A. Jaggar will complete the areal work necessary for the preparation of the Boston Folio, and will prepare a report on the Bradshaw district, Arizona. He will be assisted by Dr. Chas. Palache and Mr. Laurence La Forge.

Mr. Arthur Keith will continue areal, structural and economic surveys in the southern Appalachians. He will be assisted by Mr. H. S. Gale.

Professor J. F. Kemp will complete the field work necessary for the preparation of the Mettawee folio in New York and Vermont.

Professor Wilbur C. Knight will continue the areal and economic surveys necessary for the completion of the Laramie folio, Wyoming.

Dr. F. H. Knowlton will devote the year to the completion of reports on the fossil floras of the Puget and Laramie formations.

Mr. Waldemar Lindgren has recently returned from a winter field season in Arizona, and will spend the greater part of the coming year in the preparation of reports.

Professor H. F. Osborn will continue his investigations on vertebrate paleontology, and under his supervision special examinations will be made of the stratigraphy of the Colorado Jurassic, by F. B. Loomis, and of the Bridger, Washakie and Uinta Basins, Wyoming, by W. B. Matthew and Walter Granger, for the purpose of determining the exact stratigraphic positions of beds from which fossil collections have heretofore been made.

Professor Chas. S. Prosser will continue areal work necessary for the preparation

of the Columbus folio, Ohio. He will be assisted by Mr. E. R. Cumings.

Dr. F. L. Ransome is at present engaged in the preparation of his report on the Globe, Arizona, mining district. Later in the season he will carry on areal and economic surveys for the preparation of the Bisbee folio, Arizona, and for a report on the Bisbee mining district. Dr. J. Morgan Clements will be associated with him in this work.

Dr. Geo. Otis Smith will continue areal surveys necessary for the preparation of the Snoqualmie folio, Washington. On the completion of his field season in the Cascade Mountains he will survey the Bluehill quadrangle, Maine. He will be assisted by Mr. Frank C. Calkins.

Dr. W. S. Tangier Smith will be associated with Mr. E. O. Ulrich during the early part of the season in the study of the lead, zinc and fluorspar deposits of western Kentucky, and later will continue his investigation of the lead and zinc deposits of the Joplin district. He will be assisted by Dr. C. E. Siebenthal.

Dr. A. C. Spencer will study the areal and economic geology of the Grand Encampment mining district, Wyoming. He will be assisted by Professor J. Volney Lewis.

Dr. T. W. Stanton will continue a general supervision of the paleontologic work of the survey, and will carry on field work in cooperation with Mr. J. S. Diller in the Klamath Mountains of California.

Mr. Geo. W. Stose will continue in charge of the editing of geologic maps and will spend a short field season in the continuation of work on the Chambersburg quadrangle, Pennsylvania.

Mr. J. A. Taff will continue his areal and economic surveys in Indian Territory. He will be assisted by Professor S. W. Beyer and Mr. J. W. Beede.

Mr. E. O. Ulrich will study the geology of the western Kentucky mining district in connection with Dr. Tangier Smith's investigation of the mineral deposits. Later in the season Mr. Ulrich will be associated with Dr. Adams in Arkansas and Mr. Taff in Indian Territory.

Professor C. R. Van Hise will continue the supervision of investigations on the pre-Cambrian and metamorphic rocks of the United States. He will visit various parties in the field for the purpose of verifying and coordinating work in his division. He will be assisted by Mr. C. K. Leith in the preparation of a final monograph on the Lake Superior region, by Dr. W. S. Bayley in the completion of field work in the Menominee district, by Dr. W. H. Hobbs in the continuation of surveys in Connecticut and Rhode Island, by Dr. Florence Bascom in the continuation of areal and structural studies in the Philadelphia district.

Mr. T. Wayland Vaughan has recently returned from field work in southern Louisiana, Alabama, Georgia and Florida. He will be engaged throughout the greater part of the coming year in the preparation of a monograph on the fossil corals of the United States.

Professor Lester F. Ward will continue the preparation of reports on the Mesozoic floras of the United States.

Mr. W. H. Weed will revisit Montana for the purpose of securing additional information required for the completion of his report on the Butte mining district.

Mr. David White will continue his investigations on the paleobotany of the Carboniferous, working in cooperation with various geologists in West Virginia, Ohio, Pennsylvania and Indian Territory.

Professor Henry S. Williams will continue his studies on the correlation problems of the Devonian in Pennsylvania,

New York and Maine. He will be assisted by Mr. E. M. Kindle.

Mr. Bailey Willis will continue the supervision of the investigations in areal and stratigraphic geology. He will visit field parties in various parts of the United States and will investigate the stratigraphy along the eastern base of the Rocky Mountains in Montana and Wyoming.

Professor J. E. Wolff will continue the investigation of the areal and structural geology in the crystalline areas of New Jersey and southern Vermont.

July 12, 1902.

SCIENTIFIC BOOKS.

Lehrbuch der vergleichenden Entwicklungsgeschichte der wirbellosen Thiere. Allgemeiner Theil. Erste Lieferung. Erste und Zweite Auflage. By E. Korschelt and K. Heider. Jena, Gustav Fischer. 1902. Pp. x+538; 318 figs.

When the third and final instalment of the 'special part' of the 'Lehrbuch der vergleichenden Entwicklungsgeschichte der wirbellosen Thiere,' by Professors Korschelt and Heider, made its appearance, zoologists who had the good fortune to be familiar with the work began to look forward with no little eagerness to the appearance of the 'general part.' It was, however, a case of hope long deferred, but now, after a lapse of nine years, expectations are in the way of being fulfilled. Our knowledge of the embryology of the invertebrates has increased greatly in the interval and a demand has arisen for a new edition of the 'special part,' but the authors, feeling that they were still in debt to the public to the extent of the general part, have decided to complete the work as originally planned before beginning a revision. As a result we have now before us a first instalment of the 'general part,' which is at once an earnest for the completion of the first edition and the beginning of the second.

Zoologists will find, however, for the loss resulting from the long postponement of the volume, ample compensation in the greater thoroughness with which it is now possible to discuss the general problems of development. In the last decade the standpoint from which these problems are regarded has shifted greatly; the mountain tops, from which they were formerly seen but dimly, have been left behind and we are now upon the nearer plains, with numerous difficulties, it is true, still to be overcome, but with the advantage that we have come into actual contact with them and can, at close range, lay our plans for their surmounting. And that this is the case is largely due to the results obtained from experimental embryology.

In the present volume will be found one of the clearest and fullest statements of the results and aims of this department of investigation which has yet been presented. The first three chapters or almost half the volume is devoted to it, the first chapter, after a brief introduction discussing the influence of external stimuli on development; the second, the determination problem; and the third, the effects of internal factors. To one familiar with the 'special part' of the work it will suffice to say that the facts are presented in the present volume with the same wealth of detail and clearness of exposition that characterized the earlier volumes and to these there is again added a critical and judicious estimate of the value of the facts. The authors have carefully avoided the advocacy of extreme positions and have maintained throughout what may be termed a broadly conservative attitude, compared with views which have been promulgated by some recent writers. It is impossible to discuss here in detail the various topics considered in the volume, but a few quotations may not be out of place to indicate the standpoint of the authors on some of the more general problems which confront us.

"It results from this that we err in endeavoring to give a general answer to the question whether it is preformation or epigenesis which controls the phenomena of development. We must particularize and endeavor by experiment to answer this question for each individual stage and each form. It will be found that in many cases the development of a certain organ or some morphological relation

(axial or direction relations) is determined rather in the sense of a mosaic-work by self-differentiation; in other cases, on the contrary, it may be due to differentiation dependent upon the regulatory influences of the whole upon its parts. In many cases both these principles of development are commingled, frequently in a marvellous manner, in the formation of some complicated part, so that we must endeavor to determine by a thorough analysis in what respect self-differentiation and in what dependent differentiation predominates."

And again, "It is a question * * * whether the possibility of 'analyzing animal ontogeny into a series of induction phenomena' (Herbst) is conceivable, or whether still other components must be recognized. In this connection there is especially noteworthy the newer standpoint of Driesch, who, from the problem of the localization of the developmental processes, has been led to the opinion that other special vital components, which he figuratively terms forces acting from a distance, must be recognized. We are not yet convinced that the former of the possibilities mentioned above is at present to be regarded as completely excluded, and in this respect we agree with the conclusions of von Hanstein."

The fourth and fifth chapters, which complete the volume, treat of the ovum and oögenesis and of the spermatozoon and spermatogenesis. Here again there can be only praise for clearness in the arrangement of the topics and in their presentation, and it may be added that, for the sake of thoroughness, the germ cells of the vertebrates as well as of the invertebrates are brought within the scope of the discussion.

One is tempted to predict for the 'Lehrbuch,' when completed, an influence upon embryological research as great as that exerted by Balfour's classic 'Comparative Embryology.' Nowhere will there be found a work presenting more perfectly the facts and problems of embryology, and the gratitude of all zoologists is due to the authors for placing in their hands a book so reliable and authoritative. The concluding volume, which is to treat of maturation and fertilization, the general phenomena of segmentation and the formation of the germ layers, is promised at an early date.

J. P. McM.

Among the Water-fowl. Observation, Adventure, Photography. A Popular Narrative Account of the Water-fowl as found in the Northern and Middle States, and Lower Canada, East of the Rocky Mountains. By HERBERT K. JOB. New York, Doubleday, Page & Co. 1902. Square 12mo. Pp. xxi+224, with many illustrations from photographs by the author.

Hunting with the camera has the double advantage of not decreasing the numbers of birds, while placing the results of the chase at the disposal of the public, instead of reserving it for a chosen few. In the present volume Mr. Job presents the results of many days' enthusiastic labor on the ponds and in the marshes of Dakota, on the Magdalen Islands and the historic Bird Rocks, and among the islands off the New England coast. From these we get a very clear idea of the breeding habits of many of our water-fowl; we learn how the auk and murre build no nest at all, are introduced to the slatternly homekeeping of the grebes and are shown the well-built and warmly lined nests of the ducks. Most of the water birds that breed within the limits of the United States have posed in front of Mr. Job's camera, or if not the birds, their nests have been photographed. And of ducks alone the author tells us he has found the nests of nineteen species. Perhaps the most interesting chapters are those relating to the grebes, since from their manner of breeding the nests are not readily accessible; and these nests are so low and so carelessly built that the loss of eggs must be very great. Mr. Job aptly terms the grebes 'the submerged tenth,' and in reading his account one is led to wonder if that great diver of old, Hesperornis, bred after the fashion of the grebes, since he must have been even more aquatic in habit.

It is not pleasant to recall that these same grebes are being slaughtered by thousands on their breeding grounds in California, and it is even more painful to read of the shooting of breeding birds on the Great Bird Rock.

The Canadian Government should absolutely prohibit all shooting on the Bird Rocks and all taking of eggs after the first of June. In pleasing contrast to this Mr. Job tells of the increase of gulls and terns at some localities on the New England coast, where they have been protected. He shows us these gulls and their nests, not only on the ground, but perched in spruce trees, where most of us would hardly think of looking for such birds. The largest colony of gulls described was in Dakota, where Mr. Job found thousands of Franklin's rosy gull breeding in and about a shallow lake, the nests being so numerous as to be often within a few feet of one another. Some of the best views in the book are from this colony, but perhaps the most striking are some of gulls in full flight, taken by Mr. von Bargen in San Francisco Bay.

Not quite all of Mr. Job's hunting was done with a camera, for he gives some very vivid glimpses of sea duck shooting off the Massachusetts coast, although, truth to tell, these are the exceptions.

The ornithologist and the casual reader will find this book most enjoyable, full of pleasantly given information, accompanied by illustrations that illustrate. Some of these are not quite up to the modern standard, but when we read how many of them were obtained we cease to wonder at this, and can only admire the pluck and perseverance that obtained them. F. A. L.

Die Bakterien. By Johs Schmidt and Fr. Weis. Jena, Gustav Fischer. Pp. 406.

The extraordinary development of the science of bacteriology has resulted in the production in the last fifteen years of a large number of manuals and text-books devoted to various phases of this general subject. Books upon general bacteriology have appeared in many languages and it would hardly seem that there could be found room for another work upon the same general subject. The authors of the book before us have, however, found a niche which has been hitherto unoccupied and which they have succeeded in satisfactorily filling. Bacteriology is preeminently a *practical* study. At first it created an immense amount of interest because of its application to the fascinating subject of disease, and more recently because of its intensely practical value to the agriculturist. Most works on bacteria have, therefore, devoted at least a large part of their attention to the practical applications of bacteriology in one direction or another. The works upon bacteriology which may be now found in our libraries are devoted in part to the study of bacteria as scientific objects, and in part to their relations to disease or to natural phenomena with which they have been found to be so intimately associated. The work of Schmidt and Weis leaves out of consideration all practical considerations and all practical applications of bacteriology and is devoted wholly to the study of bacteria from a standpoint of pure science.

The authors divide the subject into three sections. In the first they study the morphology and the systematic relations of bacteria; in the second their physiological relation; and in the third the systematic relations of the most important of the species of bacteria which have been described in literature. The work has the further advantage that of the two authors, one has been able to devote himself to the morphology and systematic study, and the other to the physiological study of bacteria. The result of this is that both sides of the study of bacteriology are more satisfactorily and authoritatively treated than when a single author attempts to deal with both aspects of this somewhat complicated subject. The work becomes, therefore, one of special value; its treatment of the problems considered is clear, concise and authoritative. It shows the greatest familiarity with the most recent advances and discoveries in connection with bacteriology, and presents all of the subject considered in a clear and sometimes in a fresh light, which is very suggestive. The language which is used is simple, straightforward and extremely clear, and on the whole there is probably no work yet published which contains such a clear, concise and authoritative account of the morphology and physiology of these immensely important microorganisms.

This work must be looked upon to a large extent as an *introduction* to the study of bacteriology. After all, most people who study bacteria are sure to study them for their practical bearing upon various topics, rather than for the scientific relations of the bacteria themselves. In order to understand the relations of bacteria to disease, to agriculture or any other practical subject it is necessary, first, to have a tolerably good knowledge of the bacteria themselves. Such a knowledge is furnished by the work in question and this book will, therefore, serve as a foundation for the study of bacteria to students who are interested in the application of these organisms in any direction. No work has yet appeared which gives in such a brief space an equally clear, concise account of bacteria, their structure, their methods of development, their relations to external conditions, their distribution, their physiological relations to environment, etc., as this work by Schmidt and Weis. It is to be hoped that a translation into English may appear.

H. W. CONN.

WESLEYAN UNIVERSITY.

An Analytical Key to some of the Common Flowering Plants of the Rocky Mountain Region. By AVEN NELSON, professor in the University of Wyoming. New York, D. Appleton & Co. Pp. 94.

This little book is intended by the author to serve as an introduction to the study of Rocky Mountain plants. About four hundred species are described. It is expressly stated in the preface that the book should not take the place of a manual, and the teacher is warned not to use it for general field work. Plants should be selected for study which are described in the key. If the teacher will keep this warning in mind the work will, without doubt, be found very useful.

Hitherto it has been quite impossible to use modern nomenclature in school work in this region, because there was no work of reference containing the correct names of even our most common plants. Here is a work which, so far as it goes, is entirely modern.

It is a familiar fact, which was known even to Aristotle, that parents think most of their own children, that poets think most of their own poems. It seems now that botanists think most of their own species of plants. At least there are a good many plants in the key credited to 'Aven Nelson.' This apparent nepotism is explained when we examine the work carefully. Many of these favored species are really species quite common, but generally confused with similar species of the eastern states.

The key to the families in the front of the book seems admirably arranged to show the diagnostic characters. The plants selected to represent the different families are well selected. An important feature of the descriptions is the reference to ecological points in connection with the various species and genera. The habits and habitats are given as only one who knows the plants in the field could give them. Professor Nelson's long experience in the Rocky Mountain region has given him a mastery of the subject which no one from the eastern states could possibly have.

It is very much to be desired that in future editions of the work it may be found possible to include a few of the more common species of grasses, since they form such an important part of the earth covering. The reviewer believes that a knowledge of the morphology of the grass flower and fruit is not beyond the grasp of beginners. Species of *Agropyron* and *Stipa,* which are abundant in the region, can well be used with such students.

FRANCIS RAMALEY.

UNIVERSITY OF COLORADO.

SCIENTIFIC JOURNALS AND ARTICLES.

THE *Popular Science Monthly* for July has for its frontispiece a portrait of Asaph Hall, President of the American Association, which has just met at Pittsburgh. Cloudsley Rutter presents some 'Studies in the Natural History of the Sacramento Salmon,' giving many details in the life history of the fish, and showing the movements of the young from the time they are hatched until they reach the sea. Under the title 'A Modern Street,' S. F. Peckham describes the methods and materials employed in laying an asphalt pavement. An abstract is given of the 'Views of Dr.

Rizal, the Filipino scholar, upon Race Differences,' in which he shows how difficult it is to get an unprejudiced estimate of the Filipino character. 'Gold Mining in the Klondike' is described by Henry A. Meiers, and Edwin G. Dexter has 'A Study of Twentieth Century Success,' showing the elements of success as based upon an analysis of the information given in 'Who's Who in America.' William H. Burr discusses 'The Panama Route for a Ship Canal,' and Woodrow Wilson tells of 'Princeton in the Nation's Service.' Finally, W J McGee has a timely article on 'The Antillean Volcanoes,' and there are sundry interesting items in 'The Progress of Science.'

In *The American Naturalist* for June, J. F. McClenden gives 'The Life History of *Ululu hyalina* Latreille' and Wesley R. Coe discusses 'The Nemertean Parasites of Crabs,' concluding that all of the species show great similarity of structure, that they are true parasites and that some species are widely distributed. H. V. Wilson, in an article 'On the Asexual Origin of the Ciliated Sponge Larva,' shows that Ojima's recent observations seem to bear out his own conclusions as to this method of propagation in *Esperella fibrexilis*. J. E. Duerden, in a paper on 'Aggregated Colonies in Madreporarian Corals,' shows that these are probably due to the coalescence of larvæ or young forms and not to fission. Under the title 'Utah Chilopods of the Geophilidæ,' Ralph V. Chamberlain describes six new species and gives keys showing the position of the new forms in their genera, as well as for the identification of those already known from the West. In considering 'Color Variations of the Common Garter Snake' Edwin C. Eckel comes to the conclusion that the two subspecies of *Eutænia sirtalis, obscura* and *pallidula,* are of doubtful value, while in 'Notes on the Dispersal of *Sagartia Luciæ* Verrill' G. H. Parker presents evidence that the species is spreading northwards and eastwards. Under 'Correspondence' Dr. C. R. Eastman criticises Patten's recent paper on the Ostracoderms and particularly the conclusion that they are nearly related to the Arthropods.

The South African Museum has issued Parts VI. to VIII. of the second volume of its *Annals,* the principal paper being by W. F. Purcell, 'On some South African Arachnida belonging to the Orders Scorpiones, Pedipalpi and Solfugæ.' This comprises a revision of the South African species of the genus *Parabuthus,* descriptions of seven new species and three new varieties of scorpions; one new pedipalp, nine new species and one new genus (*Chelypus*) of Solfugæ, together with lists of new localities for various species and notes on local variations. G. A. Boulenger gives a 'Description of a New Silurid Fish of the genus *Gephyroglanic,* from South Africa,' and Walter E. Collinge presents some notes 'On a Further Collection of South African Slugs with a Check List of Known Species.'

The Plant World for May, a little belated, contains a paper by Cora H. Clarke, entitled 'New Missionary Work,' being another plea for the preservation of our wild flowers. Roland M. Harper gives some 'Notes on *Elliottia recemosa,*' giving an account of the rediscovery of this rare shrub after an interval of twenty years. A. H. Curtiss continues 'Among Florida Ferns,' and there are the customary briefer articles, including an account of the aims of the Wild Flower Preservation Society.

In *The Museums Journal* of Great Britain the most important article is the fifth and last paper on 'Hygiene as a Subject for Museum Illustration.' This completes a careful and detailed outline of the subject with diagrams showing a proposed arrangement of a Museum of Hygiene. With this, June, number the *Journal* completes its first year and Mr. Howarth is to be congratulated on the successful termination of his first year as an editor.

The American Museum Journal for May and June notes the progress in the installation of the series showing the development of the horse and the successful completion of the Saturday afternoon talks on ornithology. The supplement, this time under the modest

title of 'Guide Leaflet,' is an illustrated handbook to the butterflies found within fifty miles of New York City. It comprises 52 pages and 96 figures and should be in demand by local entomologists.

AN English dealer in minerals was the first to advertise volcanic dust from Mt. Pelée, and the British Museum is the first, and only one, to make a special exhibit illustrating the recent volcanic eruptions in the West Indies. This, as described in *The Museums Journal,* comprised a series of maps and diagrams showing the geography of the Lesser Antilles and the relations of their volcanoes to the general structure of the globe, and particularly to the disturbed area in Central America. Pictures and photographs give an idea of the scenery, buildings, vegetation and human inhabitants of the ruined islands. The poverty of the fauna and flora, due perhaps to previous eruptions, is likewise illustrated by specimens and drawings. Various products of the present and previous eruptions are exhibited and explained, while near by is an exhibit of typical volcanic products from various sources, all carefully labeled. Pictures and photographs illustrate the eruptive phenomena of other volcanoes, and extinct or possibly dormant volcanoes of other parts of the world.

SOCIETIES AND ACADEMIES.

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON.

THE 331st meeting was held April 22. Dr. Emily Brainerd Ryder gave a talk on the Parsees of Bombay, and exhibited costumes, religious objects and a model of a Tower of Silence.

Dr. Ryder spent a great many years in India, and is thoroughly familiar with the customs and religion of the followers of Zoroaster. In describing their religion she stated that before they were driven from Persia, their native country, by the Mohammedan invaders, their temples, in which the sacred and eternal fire was kept burning, were in the form of round towers, seven stories in height, seven being a sacred number in their religion. When they fled into India they decided, in order to live in peace with the Hindoos, that they would build fire temples small in size and in out-of-the-way places, so as to attract as little attention as possible. Hence, all over India their places of worship are small and obscure, in comparison with the temples and mosques of other religious bodies, notwithstanding the fact that they are the wealthiest and most progressive people in India.

In these temples the sacred fire, the symbol of Ahriman, the sun or god, burns on an altar of white stone. Three priests relieve each other at the end of every eight hours, and every time the fire is replenished with sandal wood, a gong is struck to notify outsiders that the sacred fire is being promptly tended and watched. In the opening of a new temple the fire of its altar has to be obtained from heaven; in other words, it must be a part of the divine or electric spark, and frequently it is months before this can be obtained.

According to the Zoroastrian faith, the human body, after the soul has departed, must not be allowed to pollute the air, the water, or the earth, and for that reason the Parsees have what they call their Towers of Silence, a large, round, roofless building, in which the remains of their dead are exposed to be devoured by vultures. The body is carried to its last resting place on a bier, the priest following leading a white dog of a peculiar breed with a yellow spot over either eye. Just before reaching the gate of the tower the face of the dead is uncovered, to let the sun shine upon it for the last time, after which the priest holds the dog's nose toward the face of the dead four times, and from all four quarters. The animal is called the 'four-eyed dog,' and this curious custom is so old that, in Mrs. Ryder's opinion, the Parsees have lost its meaning and significance.

'The Vinter's Bush' was the title of a paper read by Dr. H. Carrington Bolton, on the ancient custom of using a bush as a wineshop sign in the same manner that three balls are used as a sign by pawnbrokers, and a striped pole by barbers. He was followed by Mr. G. H. Matthes, who has lately returned from Sumatra, who read a paper on the Malays of

that island, illustrating his paper with a series of lantern pictures.

The 332d meeting was held May 6. Lieut. W. E. Safford, U. S. N., read a paper on the ethnobotany of Guam. Lieut. Safford remained a long time in Guam in an official capacity, and while there made an extended study of the island and its inhabitants. The paper showed the carefulness of Lieut. Safford's observations and the enthusiasm with which he took up this study. Contrary to common belief, the natives are slightly mixed and speak a pure Malayan tongue. They are industrious, own and cultivate land, and make use of the feral and introduced plants to a remarkable degree.

Dr. John R. Swanton, of the Bureau of Ethnology, gave an account of the social organization of the Haida Indians. Dr. Swanton is familiar with the language of these Indians and has studied their customs for several years.

It is an interesting fact that the Haidas set apart, near their villages, parks and playgrounds for their children. The affairs of their towns are administered by the village chief, the house chief, and the clan chief. It is, apparently, the duty of the chief to earn as much property as he can in order to give it away for the purpose of rendering himself great and of confusing his enemies.

Dr. Swanton says that the chiefs and their families have a morality of their own; that is, they must live up to their station in life.

The system of relationship is quite complicated and is diagrammatically shown by Dr. Swanton.

The supernatural beings are eagles and ravens, the raven being the greater. They believe that a supernatural being resides under the Haida land and supports it.

In discussing this interesting paper Professor McGee pointed out, in connection with the table of relationship, that the law of marriage is more stringent in a low stage of civilization than it is in a high stage of civilization, contrary to the accepted beliefs of the social organizations of the Indians.

The 333d meeting was held May 20. A portion of this closing meeting for the season was given to remarks on deceased members.

Dr. George M. Kober paid a tribute to Dr. W. W. Johnston, whose death was a severe loss to the people of Washington.

A eulogy on the late Thomas Wilson was read by Professor Otis T. Mason. Following this, an interesting paper on the origin of the United States decimal money was read by Dr. William H. Seaman.

Walter Hough.

DISCUSSION AND CORRESPONDENCE.

ZOOLOGICAL NOMENCLATURE.

To the Editor of Science: While believing that a more thorough study of the existing literature on zoological nomenclature would clear up most of Dr. Cook's uncertainties, while I would especially recommend him to read my report on the subject, of 1877, to the American Association for the Advancement of Science, and admitting for myself less familiarity with the problems of purely botanical nomenclature—there are still some points in his letter in Science, No. 392, p. 30, which seem to call for notice. The necessity for types as a basis for modern genera I appreciate, I believe, fully. It is only when hasty methods of selection, upsetting work already done and promising no more definite stability than present methods, are proposed, that any hesitation is called for.

It seems to be most difficult to induce naturalists who have not made a special study of nomenclature, to get clearly fixed the idea that nomenclature is necessarily arbitrary, and that unless this principle is admitted to start with, stability is hopeless. Thus the acceptance of the tenth edition of the 'Systema Naturæ' as the starting point, though based on sound reasons, is nevertheless an arbitrary decision, and having been generally accepted should be adhered to. Dr. Cook thinks that because certain naturalists have violated the rules excluding vernacular names, therefore violation is justified and must be accepted; but laws are not enforced in that way. The laws are intended to and will, if followed, bring about stability, but it is preposterous

to suppose stability can be attained in any other way. Supplementary rules must be expected from time to time and are fully advisable, but not revolutionary changes in the already accepted rules. No one has ever claimed, as far as I know, that the possibilities of progress in the rules are exhausted or ever will be.

I confess myself entirely unable to understand Dr. Cook's characterization of De Candolle's annotated rules as 'quite lacking in logical arrangement and definite statement.' These are the very characteristics which it seems to me they possess in an eminent degree, though naturally they do not go as far as required by the needs of science thirty-five years later. Moreover, I do not hesitate to say that 'evolutionary conceptions' of nature and systems of 'recording the results of biological study' have nothing whatever to do with the rules of nomenclature. I cannot help suspecting that the attempt to combine two or three irreconcilable categories in one system is at the bottom of Dr. Cook's difficulties. It may be practicable to devise a system which would exhibit evolutionary conceptions, and this might be very useful if it proved possible; but this system would not be that which we use for animals and plants according to Linnæus and his followers, and the two things are incapable of combination. The attempt to mix them would only result in intensified confusion.

WM. H. DALL.

SMITHSONIAN INSTITUTION,
July 7, 1902.

RANGE OF THE FOX SNAKE.

TO THE EDITOR OF SCIENCE: Traditions often develop into truths for want of critical examination at an early stage in their career.

In his very complete catalogue of New York snakes, lately issued, Mr. E. C. Eckel refers to Dr. J. A. Allen as having 'described' a specimen of the fox snake (*Coluber vulpinus*) as captured in 1861 near Wenham, Mass., and in SCIENCE of June 27 Mr. Max Morse adopts the statement and suggests that Professor Cope, in fixing the range of this species, overlooked this record.

The references which evaded the minute inspection of my late friend, Professor Cope, were very few, and fewer still, after capture, escaped from that extraordinary memory. As a matter of fact he did have this record in mind in his Check List of 1875, where Massachusetts was given as the eastern limit of this species. The fact that this reported extralimital occurrence is now unverifiable is doubtless the real reason why it was passed over by Cope in his later work, as it was by myself in preparing, two years ago, a review of North American snakes.

In reality Dr. Allen did not 'describe' this specimen, nor had he apparently ever seen it; he merely in 1869 stated that a specimen had been entered on the catalogue of the Museum of Comparative Zoology, as having been received from Wenham, Mass., in 1861, and that Professor F. W. Putnam believed the identification to be correct. That Dr. Allen himself doubted this is shown by the language of his next sentence: '*If it is* this species, etc.' Forty years ago herpetologists were less plentiful, and identification of species was less exact, than at present, and it is easily conceivable that one not fully familiar with the group might have mistaken an example of *Ophibolus doliatus triangulus* for the then little-known *Coluber vulpinus*. Indeed Baird and Girard, in the original description of the latter species, mention the similarity in general aspect of the two. That there was such an error in identification is much more likely than that a large and conspicuous species, not otherwise known east of Ohio, should have naturally occurred at a point so distant as the extreme northeastern county of Massachusetts.

A suggestive case is that of a living *Ophibolus rhombomaculatus* received by me in June of last year, with the history from a well-intentioned source, of its capture during the previous September, near Erie, Pa. Now this rather rare species has never, to my knowledge, been previously detected north of the District of Columbia, and the best explanation of its supposed occurrence at such a remote point seems to lie in an inference from the fact that the specimen had passed through the hands of a person from a southern State, who was

something of a collector without being an ophiologist of experience. The high probability that some of his snakes had become mixed has prevented a public record of this alleged locality, in the absence of further evidence.

The collector of living specimens needs especially to guard against being misled by errors of this class, for the reason that living animals are not usually labeled when collected, beyond the possibility of confusion.

A few such cases taken at random from memory in the experience of the Zoological Society are the receipt of a South American heron, said to have been captured near Portland, Oregon; a tayra from west Africa; a bald eagle from Brazil; a southern fox squirrel from Java; a North African species of hedgehog from Manila; and a coyote captured in Porto Rico by soldiers of a volunteer regiment which served in that campaign.

Arthur Erwin Brown.
Zoological Gardens, Philadelphia.

SHORTER ARTICLES.

PRELIMINARY NOTE ON A NEW ORGANISM PRODUCING ROT IN CAULIFLOWER AND ALLIED PLANTS.

During August and September of 1901 my attention was drawn to a disease of cauliflowers in the vicinity of Guelph, Ontario. The plants, which were well grown and cared for, showed symptoms of rot, the interior of the stem, and often all the flowering or edible part being changed into a dark-colored soft mass. Examination of this rotted material revealed the presence of enormous numbers of bacteria. Subsequently, the causal organism was isolated in pure culture, and its pathogenicity and relation to the rot were established by inoculation of healthy cauliflower plants, the production of rot in these plants, and the reisolation of the germ, and its cultivation on various media.

The organism is a medium-sized motile bacillus, with peritrichous flagellæ, five to nine in number, stains slowly with methylene blue (Loeffler), better with carbol-fuchsin. Grows best under aerobic conditions, but is able to grow slightly in atmosphere of hydrogen. Liquefies gelatin; grows on surface agar as a moist, whitish, slightly opalescent growth, which becomes more massive with age; curdles milk slowly, producing slight digestion, with acid reaction (litmus). Produces heavy cloudiness in bouillon. Changes the red color of rosolic acid peptone bouillon to a light brown. On slices of raw potato, produces a deep creamy growth; the potato is completely softened, with the production of a considerable amount of ammonia. Grows well on raw slices of the following vegetables, producing softening or rotting: cauliflower, cabbage, turnip, rape, radish, horseradish, kale, celery, artichoke, asparagus, carrot, onion, tomato and parsnip. It does not grow on raw beet, and on sugar beet but very sparingly.

The growth on some of the above vegetables, notably cabbage, horseradish and onion, is frequently accompanied with the production of gas bubbles, and disagreeable, offensive odors.

The organism grows best at 25–30° C., but grows well at both 20° and 37° C.

The action of the bacillus on the plant is similar to the *Pseudomonas* described by Potter. It dissolves the middle lamella; the enzyme produced by the bacillus may be isolated from the rotted cauliflower or from bouillon.

The name proposed for the organism is *Bacillus olereaceæ*.

F. C. Harrison.

July 1, 1902.

RECENT MUSEUM REPORTS.

The annual reports of three of our great museums have appeared within the last few months and may well be considered together. These, in their order of appearance, are the Field Columbian Museum at Chicago, the American Museum of Natural History of New York City, and the United States National Museum at Washington. This last is so far behind the others in date, being for the fiscal year ending June 30, 1900, that it is a little difficult to make exact comparison with them. Each of these institutions expresses a need for more money for current expenses and the National Museum makes its regular annual plea for more room. How necessary more

room has become may be partly understood by reading Mr. Rathbun's report, but only those conversant with the circumstances in the case can fully appreciate the inconvenience, loss of time and money, and danger of loss from fire caused by the existing order of things.

The city of Glasgow is just now finishing a museum that will cost $1,500,000, and it would seem that a nation so fond of boasting of its wealth as is the United States might at least spend thrice that sum in the construction of a building.

From the reports one gathers that in all these institutions there is special activity in the departments of anthropology and vertebrate paleontology, and in both of these departments the American Museum of Natural History, largely through the liberality of its friends, stands first. Through the activity of its collecting parties this institution has made good progress with its extremely interesting exhibit illustrating the history of the horse family. Although this is now much more complete than any other similar collection extant, the Curator hopes eventually to secure every form between the little Eocene ancestor and the large horse of the Pleistocene, and to add skeletons of typical breeds of modern horses as well.

In paleontology the Field Columbian Museum has added the largest bone of any animal yet found, in the shape of a femur of *Camarasaurus,* six feet eight inches high, while it has also placed on exhibition a complete foreleg of the great *Morosaurus.*

The comment may be made that all these fine fossils have been the result of field work, and that the U. S. National Museum has no funds for this purpose.

As usual the Field Columbian Museum makes a good showing in its exhibition series of mammals, the most notable being a group of African wart hogs mounted by Mr. Akeley. The piece of the year of the American Museum is the bird rock group of Mr. Denslow, and an illustrated pamphlet describing this may be had for the nominal sum of ten cents.

In entomology and botany the National Museum stands first with its accessions of 85,000 specimens of insects, arachnida and myriapoda, and 27,000 herbarium specimens, and it is a pleasure to add that the greater number of these came as gifts.

The American Museum announces the installation of the famous Bement collection of minerals and of the fine series of gems presented by J. Pierpont Morgan. The National Museum has received on deposit from Dr. Shepard the Shepard collection of minerals which includes many rare forms.

Both the Field Columbian and American Museums make provisions for lecture courses; the latter, indeed, has always made a special point of its lectures to teachers, and has a Department of Public Instruction and one of the best equipped lecture halls in the country. The one institution notes a falling off in its attendance, the other a decided increase, so that at times the lecture hall was insufficient for the accommodation of the public. The National Museum has had no lecture course for several years, but if it has not, it has imparted much direct information in response to requests from various parts of the country, to say nothing of those made by passing individuals. It is noted that 700 lots of specimens were submitted for identification, and that the number of letters answered was about 5,000. It can readily be seen that this work makes great inroads on the time of the scientific staff and clerical force, while it may be said that the direct results to the Museum are few. The indirect benefit, however, is probably considerable, though nothing like that occurring to the American Museum through its Department of Public Instruction.

The National Museum announces the completion of Jordan and Evermann's 'Fishes of North and Middle America,' the American Museum has published the last part of the important 'List of Types of Invertebrate Fossils,' while the Field Museum has issued 'A Synopsis of the Mammals of North America and the Adjacent Seas,' a work that, for the first time, places a comprehensive work on our mammals within reach of every one. The National Museum has published the most papers, as it should with its special appropriation. But this institution is very liberal in the matter of distribution, as well as in publishing

papers by others than the actual or honorary members of its staff.

In the matter of attendance the American Museum of Natural History had 461,026 visitors, the U. S. National Museum 358,587, and the Field Columbian Museum 248,408, this being a falling off from the previous year. The Field Columbian Museum is the most difficult of access locally, the National Museum is the easiest, while the American Museum has the largest adjacent population to draw from.

The expenses of the Field Columbian Museum were $160,545, of the American Museum, $191,584, and of the National Museum, $243,540. But $17,000 of this last was for publication and $28,040 for additions, rent and repairs, so that the actual cost of administration was not so great as it might seem.

NOTES ON ENTOMOLOGY.

For a number of years Dr. J. L. Hancock, of Chicago, has been studying that difficult family of grasshoppers, the Tettigidæ. He has now summarized his studies in an elegant volume.*

The work opens with an excellent general account of the family, including much interesting matter on habits, variation, protective coloring, etc. The generic and specific descriptions appear to be good, but the synoptic tables seem to be badly arranged. In fact something appears to have been omitted from several of them, so that they are of little value. The author has apparently no definite idea as to his species and varieties, for what are treated as varieties in one place are elsewhere called species. Altogether the author describes about 85 species, about 48 of which occur in the United States. Unfortunately Dr. Hancock did not see the National Museum collection in time to include two new species and one new variety that are added in an appendix. It seems probable that future study will reduce the number of species in our country.

* 'The Tettigidæ of North America,' published by special grant of Mrs. Frank G. Logan. Chicago. 1902. 188 pages; 11 plates.

Ch. Ferton, well known for his interesting ethological studies on predaceous Hymenoptera, has added another* to his long list of papers on this subject. It includes a great amount of matter of general biologic interest arranged in a number of chapters. There are notes on the variability of instinct in Hymenoptera; on the odor emitted by certain species; lists of Hemiptera, Diptera, and Arachnida gathered by various species as food for their young; on the position of the egg upon the host-insect; on the habit of *Odynerus* and *Eumenes* of suspending the egg to the end of a thread; on the means of protection of certain caterpillars against these Hymenoptera; and finally on intelligence and instinct.

Ferton attributes the curious acts of these insects chiefly to instinct, and declares that acts of intelligence are exceptional with Hymenoptera. Many that appear as such are only habits that one rarely has the opportunity to observe. To the paper are added two plates illustrative of the nesting habits of certain species.

It has long been known that the larva of *Clythra 4-punctata,* a case-inhabiting Chrysomelid beetle, lives in the nests of an ant—*Formica rufa.* But it was not known upon what they fed or how they got into the ant-nest. Mr. Donisthorpe has now settled these points, and in a very interesting article† he gives an account of the entire life history of this insect. The adult beetles escape cautiously from the ant-nest, and feed on the tender foliage of birch. The female then seeks a shrub overhanging an ant-nest and begins oviposition. She covers the egg with a case made of her own excrement, which, when dried, has much resemblance to a birch bud. The eggs are dropped upon the ant-nest and the ants carry them into their galleries. Here the larva hatches and uses the egg-case for its first protection. It feeds upon the de-

* 'Notes détachées sur l'instinct des Hyménoptères mellifères et ravisseurs, avec la description de quelques espèces,' *Ann. Soc. Ent. France,* LXX., pp. 83–148, 1901.

† 'The Life History of *Clythra 4-punctata,*' *Trans. Entom. Soc. London,* 1902, pp. 11–24, 1 pl., by H. St. John K. Donisthorpe.

caying vegetable matter that it finds in the nest, and enlarges its case by using its excrement to solder bits of dirt together. When ready to pupate, it fastens the case to a piece of wood or twig, and turns completely around, end for end. The beetle escapes by biting a circular cap from the case. The ants are apt to attack and kill the beetle, so that it has to be careful in getting out of the nest.

In the new publication—*Fauna Arctica*—edited by Drs. F. Römer and F. Schaudinn, there have appeared two papers on arctic insects. One, on the Collembola,* is by C. Schaeffer, and the other, on the Lepidoptera,† is by A. Pagenstecher.

In the former there is a complete bibliography, and then an annotated catalogue of the 61 species of spring-tails known from the arctic and subarctic regions. This is followed by a tabulated statement of the distribution of the species. Schaeffer records several species from the United States not previously known to occur here; these are *Achorutes tullbergi* var. *concolor, Isotoma cinerea* and *Tomocerus vulgaris* var. *siberica,* all from Massachusetts.

In the two hundred quarto pages of Dr. Pagenstecher's work there are catalogued nearly 1,000 butterflies and moths from the arctic and nearby regions. The full synonymy is given, and many notes on distribution. The catalogue is preceded by an annotated bibliography, containing much interesting matter.

Catalogues seem to be the order of the day, and Darboux and Houard have written one that will be as useful as any. It is a descriptive catalogue‡ of the European galls, or plant deformations caused by animals. It is arranged alphabetically according to the host plant. Under each plant is a tabular synopsis of the species found on that plant. This synopsis is based on the nature and shape of the deformation, and not on the characters of the animals. The great majority belong to three groups, the Cecidomyidæ of the Diptera, the Eriophyidæ (Phytoptidæ) of the Acarina, and the Cynipidæ of the Hymenoptera. Over 4,000 kinds of galls or deformations are thus treated. This volume is to be followed by another containing a supplement, references to all the described species and descriptions of new forms.

Dr. M. Régimbart has published a monograph of the large beetles formerly placed in the genus *Hydrophilus.** We have two of these species in the United States; one of them is very commonly found under electric lights in the cities. This is now known as *Stethoxus triangularis* Say, while the rarer species (*ovalis* Ziegler) is placed in the new genus *Dibolocelus.*

Dr. F. Meinert has completed a study of the larvæ of the coleopterous family Dytiscidæ.† Unfortunately it is published in Danish, but there is a French résumé, from which one may gather the main facts of the article. However the larval characters of the genera and species are in Latin. The larvæ of 49 species are described, and, in many cases, figured. Upon a study of these larvæ he bases a new classification of this and allied families included in the Caraboidea of Ganglbauer. The six families he reduces to four. The Carabidæ includes the Carabinæ, and the Cicindelinæ; the Dytiscidæ includes the Dytiscinæ, Pelobiinæ, Noterinæ and Amphizoinæ. The Halipidæ and Gyrinidæ stand as usual.

In the *Journal of the Hungarian Department of Agriculture* Joseph Lósy has published a very full account of the bee-louse, *Braula cæca.*‡ The text is in Magyar, but one may gain much information from the many large and excellent figures. The article deals chiefly

* *Fauna Arctica,* Vol. I., 2d part, Article No. VII., 1900.

† *Fauna Arctica,* Vol. II., 2d part, Article No. VI., 1901.

‡ 'Catalogue systématique des Zoocécidies de l'Europe et du bassin méditerranéen,' by G. Darboux and C. Houard. Paris, 1901, 543 pp., 863 figs. Volume supplémentaire du *Bulletin Scientifique de la France et de la Belgique.*

* 'Revision des grands Hydrophiles,' *Ann. Soc. Ent. France,* LXX., pp. 188–230, 1902.

† 'Vandkalvelarverne (Larvæ Dytiscidarum),' *Kgl. Danske. Vidensk. Selsk. Skr.* (6), Vol. IX., No. 8, 1901, pp. 341–440, 6 plates.

‡ 'A méh és a méhtetü együttélése,' *Kisérletügyi Közlemények,* Vol. V., Part 2 (1902), pp. 163–203, 3 plates, 6 figures.

with the external anatomy of *Braula,* especially with the structure of the mouth-parts; but there is an historical account of the insect and a consideration of its relations to the bee.

An interesting little book has been written by L. C. Miall as an introduction*to the study of economic entomology. The work is divided into four portions; I., Preliminary lessons; II., Lessons on common insects, chiefly such as are either injurious or useful to man; III., Descriptive account of the larger orders of insects, with short notices of remarkable forms; IV., The destruction or mitigation of insect pests. The book is devised especially for English students, but the introductory structural and biological features would be of much help to Americans. Indeed on these points it is plainly superior to most of our works on economic entomology, and indicates the lines along which our text-book could be improved. The economic accounts of the various species treated are frequently of interest to us, and the chapter on insecticides is largely drawn from American sources. The outline figures are good; and the book will undoubtedly do much to broaden the knowledge of economic entomology in England.

Nathan Banks.

BOTANICAL NOTES.

TWO TEXT-BOOKS OF BOTANY.

Among recent books designed for the use of students is Professor Heald's 'Laboratory Manual of Elementary Biology' (Clute & Co.), Part I. of which interests us here, as it alone is devoted to plants. This book is interesting as coming from a teacher who has had to solve the problem of the best method of presenting the subject to beginning classes. The method adopted is described by the author as a mean between the 'verification method' and the 'question method,' neither of which he fully approves. Directions are given for making particular observations, and some questions are asked, but at the same time much information is given in the text. Apparently the author has succeeded in quite successfully steering the middle course which he approves. In taking up the subject he begins at once with the lower plants, and makes this excellent contribution to the pedagogics of botany in his preface: "No excuse need be offered for beginning with the simple forms and ending with the complex. Experience has shown that the logical order can be carried out with even more satisfactory results than the illogical order of complex first and simple forms later." The book is remarkable in containing no illustrations whatever, and may thus be regarded as a protest against the excess of illustrations found in so many recent books. Professor MacDougal's little book, 'Elementary Plant Physiology' (Longmans, Green & Co.), reminds us of his earlier work, 'Experimental Plant Physiology,' which in fact it is intended to replace. The sequence of topics is quite different, however, in the new book, and many new illustrations have been added. After a useful introductory chapter devoted to material, measurements, etc., the author takes up 'Growth,' following this with 'Reproduction and Germination.' Then follow chapters on 'Exchange and Movements of Gases and Liquids,' 'Nutrition,' 'Respiration, Digestion and Fermentation' and 'Stimulation and Correlation.' The physical aspects of physiology are thus first taken up, and then the chemical aspects, followed by what may be called the vital aspects. Here again we detect a suggestion as to the proper sequence of topics in the study of plants and their activities. The book will no doubt become popular.

FURTHER STUDIES OF CELLULOSE.

Several years ago a notable work appeared from the hands of C. F. Cross and E. J. Bevan under the simple title of 'Cellulose' (Longmans), which at once took place as a standard reference book in botanical laboratories. Recently the same authors have prepared another book, 'Researches on Cellulose,' brought out by the same publishers, which is intended to supplement the former work. It gives a brief account of the researches published since the issue of the earlier book,

*'Injurious and Useful Insects,' London, 1902, 8vo, pp. 256, figs. 103.

in addition to some investigations of the authors themselves. The book follows the general plan of its predecessor, but no attempt is made to give it the form of a connected record. The earlier book must be in the hands of the reader in order that the results here given may be understood. The original papers are summarized under their proper headings, and references are made to the places of publication. The attempt has been made 'to reproduce the authors' main conclusions, and in most cases without comment or criticism.'

It is quite impossible to review a book of this kind; it must be read by the person interested. To show the value of the book to plant physiologists we may quote from the introductory chapter (pp. 8, 9): "These researches of Fenton's appear to us to have the most obvious and direct bearings upon the genetic relationships of the plant furfuroids, and not only *per se*. To give them their full significance we must recall the later researches of Brown and Morris, which establish that cane sugar is a primary or direct product of assimilation, and that starch, which had been assumed to be a species of universal *matière première*, is probably rather a general reserve for the elaborating work of the plant."

STUDIES OF THE STRUCTURE OF MOSSES.

WE have had occasion heretofore to call the attention of botanists, especially of non-professionals, to the help that may be obtained from certain special periodicals which are too often overlooked by the very persons who might receive benefit. It is all very well for the general student of science to read general journals, but he misses much if he does not read these special journals also. Thus there are many amateur botanists who are interested in the structure and classification of the mosses who would be greatly helped by reading the papers in the current numbers of the *Bryologist*. Dr. Grout, the editor, began some months ago a series of papers on the *peristome* of the moss fruit, and from those which have appeared we may judge as to the high value they will have for the beginner in bryology. Every one who has attempted to work the mosses has found out that this is one of the difficult structures to understand, and for the solitary student who has no handy and obliging professor to whom to appeal such help as is given in Dr. Grout's papers must prove invaluable.

THE IGNORING OF BEGINNERS AND AMATEURS.

WHEN we take up special journals like that referred to above, we are reminded that the beginner has a hard time of it now-a-days. Most journals ignore him—that is, journals of high standing and scientific reputation. One is sometimes tempted to wish that the large botanical journals might not forget that there are a great many people who are still beginners in botany, and that there always will be many beginners. The writer remembers when the American journals of botany were edited by beginners, for beginners, and he wonders whether they were not even more useful than now, for they offered to other beginners a means for 'getting up in the world,' which they scarcely do to-day. Then they were botanical ladders let down in the midst of students who wanted to learn, but now these ladders have been pulled away above the reach of the beginner. This is not always the fault of the editors. Not long ago an editor, in commenting upon the suggestion that this journal should contain more for beginners and amateurs, said that he had been criticised repeatedly by prominent scientific men for admitting even a very little of such elementary matter. Evidently some men who attain eminence forget the helps which enabled them to succeed, a state of mind which is certainly not to be commended. Let such repeat to themselves the text: 'For none of us liveth to himself.' No man should be impatient of the elementary work which is so necessary in order that beginners in science may attain to something.

CHARLES E. BESSEY.
THE UNIVERSITY OF NEBRASKA.

SCIENTIFIC NOTES AND NEWS.

M. BOUVIER has been elected a member of the Paris Academy of Sciences in the section of anatomy and zoology. Others who received

votes were MM. Houssay, Henneguy and R. Blanchard.

Dr. Florentino Ameghino has been appointed director of the National Museum of Buenos Aires as successor to the late Professor Charles Berg.

It is expected that Dr. W. W. Keen, professor of surgery at Jefferson Medical College, will reach Philadelphia by September 20, 1902, after having completed a tour of the world.

The condition of Dr. Charles Kendall Adams, the former president of the University of Wisconsin, who is ill at Redlands, Cal., is greatly improved.

We hear with regret that Dr. George Mann Richardson, professor of organic chemistry at Stanford University, is critically ill at Baltimore.

Mr. C. G. Pringle has been appointed keeper of the herbarium of the University of Vermont.

Mr. W. H. Evans, of the office of Experiment Stations, U. S. Department of Agriculture, has returned from Porto Rico, where he was in conference with Mr. F. D. Gardner, in charge of the Porto Rico Station, with reference to the selection of a permanent site and the development of the station there.

Mr. Ernst A. Bessey, special agent of the U. S. Department of Agriculture, sailed for Europe and Asia on the second of July. He is commissioned to visit Russia and Turkestan before his return.

Professor Baldwin Spencer and Mr. J. F. Gillen have returned to Melbourne from their expedition to the northern interior of Australia.

A Swedish expedition under Dr. P. Rubin is taking meridian measurements on the islands north of Spitzbergen. Dr. von Zeipel is astronomer and Lieut. Duner cartographer of the expedition.

The funeral services of M. Faye, the eminent astronomer and geodesist, took place on July 7, when addresses in his memory were made by M. Janssen, director of the Observatory of Meudon; General Bassot, president of the Bureau of Longitude, and M. Loewy, director of the Observatory of Paris.

Dr. Thomas H. Hoskins, at one time a physician and teacher of anatomy, but for the past thirty-five years engaged in agricultural experiments and writing, has died at his home at Newport, Vermont, at the age of seventy-four years.

Mr. J. Pierpont Morgan has presented to the Museum of the Jardin des Plantes, Paris, the collection of precious stones formed by Mr. George F. Kunz for the Buffalo Exhibition.

Mr. Andrew Carnegie has offered to give about $200,000 for four libraries in England.

The Royal Academy of Belgium will make at the close of the year 1904 the first award of its Ch. Lagrange prize. The value of the prize is 1,200 frs., and the subject is a contribution to geodesy.

The plan is being considered of holding a world congress of tuberculosis in St. Louis in 1904. Dr. George Brown, secretary of the American Congress of Tuberculosis, has taken steps toward the organization of the congress.

Messrs. D. Appleton & Company announce that they will publish in the autumn a volume of letters from Charles Darwin.

The second of the two annual *conversaziones* of the Royal Society was held at Burlington House on the evening of June 18, the fellows and guests being received by the president, Sir William Huggins. The London *Times* states that the exhibits were, with few exceptions, the same as were shown in May, but makes reference to some of the more attractive new exhibits. The model of the Antarctic exploring ship, the *Discovery,* exhibited jointly by the Royal Society and the Royal Geographical Society, naturally attracted considerable attention. Mr. Henry Crookes exhibited specimens of volcanic dust from the West Indies with micro-photographs and microscopic slides of the same. Exhibits by Dr. F. W. Gamble and Mr. Frederick Keeble, illustrated the color changes of crustacea, especially in response to light, and under the influence of background. Another specially noteworthy exhibit was Dr. Traver's elaborate

apparatus for liquefying hydrogen. Mr. E. J. Bles's living tadpoles of the Cape clawed frog well repaid study, as their remarkable transparency showed much of their internal economy. Mr. W. Gowland's Japanese pictures of Buddhist divinities and saints by old masters were curious examples of the art of Japan, and Mr. Edward Whymper's beautiful photographs from the Rocky Mountains of Canada, where he spent the greater part of last year, were of great interest. Professor Garwood exhibited examples of telephotography in the Alps and Himalayas. Professor Ramsay showed an attempt to reproduce the Aurora Borealis by taking advantage of the krypton element in the atmosphere. Professor Flinders Petrie showed some striking slides illustrative of the early civilization of Egypt. Mr. J. Y. Buchanan exhibited a series of slides illustrating the performance of M. Santos Dumont's dirigible balloon and the accident to it in February last, and Professor E. B. Poulton illustrated by means of very successful three-color slides, some of his recent work upon protective resemblance and mimicry in insects.

THE seventh annual congress of the South-eastern Union of Scientific Societies was, says *Nature*, held at Canterbury on June 5–7. Thirty-seven societies are affiliated, a slight increase on last year; the accounts showed a small balance, and the attendance was good. An invitation to meet at Dover next year was accepted, and Sir Henry Howorth, F.R.S., was elected president for that meeting. Papers were read on 'The Marine Aquarium,' by Mr. Sibert Saunders, and on 'Mycorhiza,' by Miss A. Lorrain Smith; Professor Poulton gave a lecture on 'Recent Researches on Mimicry in Insects,' illustrated by lantern-slides in natural colors; a discussion on the measure to be adopted for the preservation of British indigenous flora was initiated by Professor Boulger and Mr. E. A. Martin; and papers on 'Well-sections,' by Mr. Whitaker, and on 'Eolithic Flint Implements,' by Mr. E. R. Harrison, were taken as read, but will appear in *The South-Eastern Naturalist* for 1902. The event of the meeting, however, was the address by the president, Dr. Jonathan Hutchinson, F.R.S., on leprosy, with special reference to its antiquarian aspects, with reasoned argument against the theory of contagion. The congress was held, by permission of the governors, in the Simon Langton Schools, where an excellent local museum had been got together, including marine aquaria exhibited by Mr. Saunders, Mr. Harrison's eoliths, and many fresh specimens of the British orchids, so well represented in the district. The members visited the cathedral, and were entertained at the deanery by the Dean and Mrs. Farrar, and were also received, on the Friday evening, by the Mayor and Mayoress. The congress terminated on the Saturday afternoon in a visit to the South-Eastern Agricultural College, Wye, at the invitation of the principal, Professor A. D. Hall, where the members were shown over the farms and laboratories by the staff of the college.

CONSUL-GENERAL W. R. HOLLOWAY sends the following to the Department of State, from St. Petersburg: The official report of the International Exhibition of Fishery, which was held at St. Petersburg, January 28 to March 9, 1902, has just been published. The countries participating were Russia and Finland, Austria, Belgium, Germany, Denmark, Egypt, India, Spain, Italy, Monaco, Norway, Persia, Roumania, Siam, France, Sweden and Japan, the first making much the best exhibit; but as a whole, the exhibit was not up to the standard of previous ones, the participants, Russia excepted, taking little or no pains to make a creditable display.

UNIVERSITY AND EDUCATIONAL NEWS.

IT is announced that Mrs. Thomas G. Bennet, of New Haven, is the donor of the new clinical building for the Yale Medical School, the cost of which with the land is $96,000.

IT is reported that Northwestern University will receive about $200,000 by the will of the late James F. Robinson.

BY the will of the late Dr. Anson Judd Upson, Hamilton College receives a bequest of $5,000, subject to a life interest.

MR. B. F. HAWKLEY, representing the trustees of the late Cecil Rhodes, has addressed a

letter to Secretary Hay, copies of which have been forwarded to educational authorities. The letter says: The trustees are desirous of making regulations with regard to the method by which qualifications of candidates are to be ascertained, and as to examinations. They will, therefore, be obliged if you will be so good as to bring the scholarship provisions of Mr. Rhodes's will to the notice of your Government, with the request on their behalf that the views of the chief officials having control of education in the various States and Territories of the Union may be ascertained and communicated to the trustees. It would be of further great assistance to the trustees if they could be furnished, through your kindness, with the opinion of the leading educational authorities of the United States, especially the heads of Harvard, Yale, Columbia and other universities with regard generally to the election of qualifying students and the best mode of giving practical effect to the scholarship trust. It is hoped that the students can be elected in time to go into residence at Oxford in 1903.

Dr. F. E. Clements, of the University of Nebraska, will open again his summer school in the Rocky Mountains during the month of August, for the special study of the ecology of mountain vegetation.

There will be a civil service examination on August 12 to fill the position of teacher of agriculture in the Indian service at a salary of $900–$1,000.

Professor Rufus W. Stimson has been elected president of the Connecticut Agricultural College. He has been acting president since last September.

Professor John Fryer, who holds the chair of oriental languages at the University of California, has been appointed to the presidency of the new Chinese university at Wuchang.

Mr. James W. Wilson, son of Secretary Wilson, has been elected director of the South Dakota Agricultural College and Station, and will have charge of the work in animal husbandry.

Dr. E. C. Jeffrey, now instructor in the University of Toronto, has been appointed assistant professor in vegetable histology and general morphology in Harvard University.

Dr. Robert M. Bird, at present at the Mississippi Agricultural College, has been made acting professor of chemistry at the University of Missouri and acting chemist of the Agricultural Experiment Station.

Professor F. C. Waugh, of the experiment station at Burlington, Vt., has been called to the chair of horticulture of the Massachusetts Agricultural College at Amherst, Mass.

Robert Stanley Breed, Ph.D. (Harvard, 1902), has been appointed professor of biology and geology at Allegheny College, Meadville, Pa. Mr. William Albert Willard, A.M., Morgan fellow in zoology at Harvard in 1900–1901, who took the place of Professor Norris during his absence in Europe in the year 1901–02, has been appointed instructor in zoology in the University of Nebraska.

We learn from the *Botanical Gazette* that Miss Laetitia M. Snow has been awarded the fellowship given by the Baltimore Association for the advancement of the university education of women. Miss Snow will continue her botanical studies at the University of Chicago.

Professor Haven Metcalf, who for the past year has been fellow in botany in the University of Nebraska, has been elected to the professorship of botany in Clemson College, South Carolina.

The following changes and additions have been made in the medical faculty of the Columbian University: Dr. Walter Reed, U. S. A., has been elected to the chair of general pathology; Dr. Sterling Ruffin, to the vacancy in the chair of practice of medicine; Dr. Thomas Claytor, to the chair of materia medica and therapeutics; Dr. H. B. Deale, as professor of clinical medicine; Dr. H. N. Hawkes, as professor of clinical medicine; Dr. James Carroll, as associate professor of pathology and bacteriology.

Dr. David Hilbert, professor of mathematics at Göttingen, has been called to Berlin.